CHAPTER - I
INTRODUCTION

1.1.0 Background of the Study
1.2.0 Theoretical Framework of the Study
1.3.0 Need and Significance of the Study
1.4.0 Statement of the Problem
1.5.0 Operational Definitions of the Key Terms
1.6.0 Variables of the Study
1.7.0 Objectives of the Study
1.8.0 Hypotheses of the Study
1.9.0 Methodology in Brief
1.10.0 Scope of the Study
1.11.0 Delimitations of the Study
1.12.0 Organisation of the Report
INTRODUCTION

Science has been man’s greatest friend since the dawn of civilisation. It is a dynamic, expanding body of knowledge, covering wide domains of experience and is ultimately a social endeavour. Science, tempered with wisdom, is the surest and the only way to human welfare. This conviction provides the basic rationale for science education (National Curriculum Framework, 2005).

Science is an area in the curriculum that has always posed problems to majority of the students. Educationists, psychologists and philosophers have tried their best to develop new strategies, approaches and methods to make science education more effective. People today are faced with an increasingly fast-changing world where the most important skills are flexibility, innovation and creativity. According to NCF (2005) one of the basic criteria of validity of a science curriculum is process validity, which helps the student in ‘learning to learn’ science and requires the curriculum to engage the learner in acquiring the methods and processes that lead to generation and validation of scientific knowledge, and nurture the natural curiosity and creativity of the child in science.

Education is intended to encourage the students to analyse their experience and evaluate it, to doubt, to question, to investigate and to think and find independently. Learning to think is the prime function of education. Science is actually nothing more than a refinement of everyday thinking of an ordinary man. So science education cannot justify itself for remaining content merely with the objective of imparting a quantum of scientific knowledge. It should train young minds and help them develop different skills needed for a successful life. Science should emerge as something alive and exciting which will meet the wider aims of science education. Therefore the view of NCF (2005) that ‘good science education is true to the child, true to life and true to science’ is meaningful and to be considered as important, at all the stages of science education.

1.1.0 Background of the Study

India made significant advancement in the field of mathematics, medicine, astronomy, agriculture and architecture till 600AD. Indians developed their own
techniques and methods of developing scientific knowledge such as observation and logical analysis to arrive at a generalisation. The trends in science education in western countries were followed in India at a slower pace. With the British conquest of India modern Science was introduced here, with new branches and methodology.

In the beginning of the 20th century science was dealt only in universities at a surface level and it was not included in the school curriculum. The government of India appointed a number of committees and commissions such as University Education Commission (1949) and Secondary Education Commission (1952) to develop curriculum, text book and study materials under the leadership of eminent educationists. Their recommendations led to the development of science curricula and establishment of science as a core subject. The report of secondary education commission 1953, recommended that general science should be taught as a compulsory subject in high school and higher secondary classes.

The Indian Education Commission (1964-66) observed that our science education is bad in shape and in order to overcome this challenge the commission recommended that:

- Science and mathematics should be taught on a compulsory basis to all pupils as part of general education in the first ten years of schooling.
- Science teaching in the lower primary classes should be related to child’s environment.
- At the primary stage, emphasis should be on the acquisition of the knowledge and ability to think logically, to draw conclusions and to make decisions at a higher level.
- A disciplinary approach to the teaching of science will be more effective than the general science approach.
- The method of teaching science should be modernized, stressing the investigatory approach and the understanding of the basic principles.

In 1968 the national Policy on Education was declared for the first time after India’s independence, aiming at national progress. It emphasised the need for
a reconstruction of educational system with greater importance to science and technology. As a result of the implementation of National Policy on Education (NPE, 1968) science and mathematics were incorporated as compulsory subjects. In 1986 a new policy of education has been formulated by government of India which insists that the national system of education should be based on a national curriculum framework. National Policy on Education (NPE, 1986) reaffirmed the policy of NPE (1968) that science and mathematics should remain as compulsory subjects in the first ten years of schooling. NPE (1986) suggested the following:

- The science teaching and learning should be designed in such a way that it should ensure the right of the child to learn. The science education at the elementary level should provide the child the enjoyment of learning instead of loading with content.
- Science curriculum for general education should be implemented in the pacesetting schools with sufficient experimentation and innovation.
- Science up to class ten should be treated as one. It should be taught with close relation to the environment of the child by giving priority to activities.

The revised National Policy on Education (NPE, 1992) recommends designing science education programmes to enable the learner to acquire problem solving and decision making skills. The policy has stated that the science education should be strengthened so as to develop in the child well defined abilities and values such as the spirit of inquiry, creativity, objectivity, the courage to question and an aesthetic sensitivity.

NCF (2005) focuses on the primacy of the learner and child centred pedagogy. It discusses the nature of knowledge and the need for adults to change their perceptions on the child as a passive receiver of knowledge; rather the child can be an active participant in the construction of knowledge by encouraging children to ask questions, relate what they are learning in school to things happening outside, encouraging them to answer from their own experiences and in their own words rather than by memorising. The approach to planning lessons
must therefore move to preparing plans, activities that challenge children to think and try out what they are learning.

NCF (2005) insists that at the secondary stage, students should be engaged in learning science as a compulsory discipline and the science curriculum should possess the following basic criteria of validity such as cognitive validity, content validity, process validity, historical validity and environmental validity.

According to the National Focus Group on Teaching of Science (NFGTS, 2005) science education should enable the learner to:

- Know the facts and principles of science and its applications, consistent with the stage of cognitive development,
- Acquire the skills and understand the methods and processes that lead to generation and validation of scientific knowledge,
- Develop a historical and developmental perspective of science and to enable her/him to view science as a social enterprise,
- Relate to the environment, local as well as global, and appreciate the issues at the interface of science, technology and society,
- Acquire the requisite theoretical knowledge and practical technological skills to enter the world of work,
- Nurture the natural curiosity, aesthetic sense and creativity in science and technology,
- Imbibe the values of honesty, integrity, cooperation, concern for life and preservation of environment, and
- Cultivate ‘scientific temper’-objectivity, critical thinking and freedom from fear and prejudice.

Kerala Curriculum framework (KCF, 2007) is a curriculum revision programme in Kerala, conceptualized on the basis of the recommendations of NCF (2005). KCF (2007) observes the following major criticisms against the prevailing science education.

- There is a belief that the aim of science education is to transmit knowledge that has already been gathered.
- The learning process is neither process-oriented nor learner-centred.
- There is a tendency to promote rote learning of concepts in science to excel in examination and the innate curiosity and scientific temperament of the learner are neglected.
- Learning of science fails to become interesting and challenging to the learner.
- Science education has yet to become life related.

KCF (2007) stands for science teaching which highlights awareness of science and scientific literacy. It suggests that the pivot of science education should be the development of the spirit of scientific inquiry and proposed a learning methodology which is activity based. The aims of science education according to KCF (2007) are:

- Development of scientific temperament and its application in daily life
- Engagement in scientific methods like observation, experimentation, data collection, interpretation of data, analysis, theorizing, examining for construction of knowledge
- Nurturing the ability to examine scientifically the problems of daily life as well as the social issues and seeking logical solutions
- Recognising and developing one’s own interests and abilities in technical and vocational fields
- Encouraging the development of logical thinking
- Imbibing a humanistic outlook and developing a world view based on it
- Nurturing lateral thinking for enabling the learners to look at things from different perspectives and to seek new solutions
- Developing scientific literacy that provides for building awareness of scientific process

Though the recommendations of NCF (2005) and KCF (2007) have implemented in schools the status of science education has not yet improved. As the learning of science demands cognitive training, proper methods, models, strategies and innovative approaches which facilitate such training should be
sought. Cognitive Acceleration Approach is one such approach which facilitates the advancement of children’s thoughts from the concrete to the formal operational level and is a powerful tool for enhancing pupils’ capabilities in understanding science concepts. The investigator intended to experiment the effectiveness of Cognitive acceleration Approach on revitalising science education.

1.2.0 Theoretical Framework of the Study

Cognition is the scientific term for the process of thought. The term refers to the mental processes involved in gaining knowledge and comprehension, including thinking, knowing, remembering, judging, and problem solving. Cognitive development is the emergence of the ability to think and understand. It is the construction of thought processes, including remembering, problem solving, and decision-making, from childhood through adolescence to adulthood. The major theories related to cognitive development, Cognitive Acceleration Approach, Thinking Skills, Attitude and Academic achievement are dealt within details.

1.2.1 Cognitive Development Theories

A large fraction of research has gone into understanding how a child visualizes and learn about the world. Piaget (1952) was a major proponent in this field. Vygotsky (1978) used a socio-cultural approach to elucidate the development of cognition. In recent years, however other models such as information-processing theories, neo-Piagetian theories have been advanced. These theories incorporated Piaget's ideas with more recent models and concepts in developmental and cognitive science, theoretical cognitive neuroscience and cognitive acceleration approaches.

1.2.1.1 Cognitive Development Theory by Jean Piaget (1896 - 1980)

Piaget (1952) studied the evolution of children’s thinking. He sees the child as an active processor of new impressions and experiences which lead to thinking. Children construct knowledge through the development of understanding of number, time, space, velocity, geometry, chance and morality from birth to
adolescence. He theorised that there is a genetic influence to higher order mental processes, in which thinking evolved from biological mechanisms, rooted in the development of an individual’s cognitive structures.

According to Piaget, cognitive development occurs through the interaction of innate capacities of a child with environmental events and progresses through a series of hierarchical stages. The stages are same for everyone irrespective of the culture. All children pass through the stages in the same series without skipping any or moving back to earlier ones. The principal cognitive structure that changes is the schema. There are certain fundamental aspects of the developmental process which work in the same way through the various stages. The most important of these are assimilation, accommodation and equilibration.

**Schemas:** Schemas are the basic building blocks of intelligent behaviour. These are mental structures which organise past experiences and provide a way of understanding future experiences. Life begins with simple schemas but as we grow our schemas become increasingly complex.

**Assimilation, Accommodation and Equilibration:** Assimilation is the process by which the new information is incorporated into existing schemas. The process of changing existing schemas to fit the new experiences is accommodation. When a child can deal with new experiences by assimilating them, it is in a state of equilibrium and this is brought about by the process of equilibration. But if the existing schemas are insufficient to cope with new situations, cognitive disequilibrium occurs. To restore the equilibrium the existing schema must be extended to take in new information.

**Stages of Cognitive Development**

The theory of cognitive development, developed by Jean Piaget, proposes four distinct, increasingly sophisticated stages of mental representation that children pass through on their way to an adult level of intelligence. The four stages, roughly associated with age are; Sensorimotor, Pre-operational, Concrete operational and Formal operational.
**Sensorimotor Stage (zero to two years):** The sensorimotor stage is the first of the four stages of cognitive development. In this stage, infants construct an understanding of the world through their senses by doing. An infant progresses from reflexive, instinctual action at birth to the beginning of symbolic thought towards the end of the stage. According to Piaget acquiring the sense of object permanence is one of the most important accomplishments of this stage.

**Pre-operational Stage (two to seven years):** The characteristic of the pre-operational stage is sparse and logically inadequate mental operations. During this stage, the child learns to represent objects by images, words, and drawings. The child is able to form stable concepts as well as mental reasoning and magical beliefs. The child however is still not able to perform operations. Thinking is still egocentric and the child has difficulty in taking the viewpoint of others. Two sub stages can be formed from preoperational thought.

i) *The Symbolic Function Sub-stage:* It occurs between about the ages of two and four. The child is able to devise designs of objects that are not present. Other examples of mental abilities are language and pretend play. Children are unable to distinguish between their own perspective and that of others. They believe that inanimate objects are capable of actions and have lifelike qualities.

ii) *The Intuitive Thought Sub-stage:* It occurs between about the ages of four and seven. Children tend to become very curious and ask many questions. Piaget calls it the intuitive sub stage because children realise they have a vast amount of knowledge but they are unaware of how they know it. In this stage children focus all attention on one characteristic compared to the others and they haven’t the awareness that altering the appearance of a substance does not change its basic properties. Piaget considered that children primarily learn through imitation and play throughout these first two stages, as they build up symbolic images through internalised activity.

**Concrete Operational Stage (seven to eleven years):** The Concrete operational stage that follows the Pre-operational stage occurs between the ages of seven and
eleven and is characterized by the appropriate use of logic. Important processes during this stage are:

i) Seriation – the ability to sort objects in an order according to size, shape, or any other characteristic.

ii) Transitivity – the ability to recognise logical relationships among elements in a serial order.

iii) Classification – the ability to name and identify sets of objects according to appearance, size or other characteristic, including the idea that one set of objects can include another.

iv) Decentering – the child takes into account multiple aspects of a problem to solve it.

v) Reversibility – the child understands that numbers or objects can be changed, and then returned to their original state.

vi) Conservation – understanding that quantity, length or number of items is unrelated to the arrangement or appearance of the object or items.

vii) Elimination of Egocentrism – the ability to view things from another's perspective.

**Formal Operational Stage (eleven years onwards):** The formal operational stage is the fourth and final stage of cognitive development in Piaget's theory and continues into adulthood. In this stage, individuals move beyond concrete experiences and begin to think abstractly, reason logically and draw conclusions from the information available, as well as apply all these processes to hypothetical situations. Adolescents begin to think more as a scientist thinks, devising plans to solve problems and systematically testing solutions. They use hypothetical-deductive reasoning, which means that they develop hypotheses, and systematically deduce, or conclude, which is the best path to follow in solving the problem. During this stage the young adult is able to understand such things as logical proofs and values, begins to entertain possibilities for the future and is fascinated with what they can be.
1.2.1.2 *Social Development Theory by Vygotsky (1896-1934)*

Vygotsky (1978) conceives the development of thinking in a social setting. He articulates three main tenets to explain how cognition evolves. He recognises the influence of genetic inheritance and development, the role of social interaction with others in promoting thinking and the ways in which language was used to stimulate and shape children’s thought.

According to the theory, social interaction plays a fundamental role in the process of cognitive development. Humans use tools that develop from a culture, such as speech and writing, to mediate their social environments. Initially children develop these tools to serve solely as social functions, ways to communicate needs. Vygotsky believed that the internalisation of these tools led to higher Thinking Skills.

Culture makes two sorts of contributions to the child’s intellectual development. First, children acquire much of their thinking from it. Second, children acquire the processes or means of their thinking from the culture. Therefore, culture provides the children with the means to, what to think and how to think. Vygotsky viewed cognitive development as a result of a dialectical process, where the child learns through shared problem solving experiences with someone else, such as parents, teacher, siblings or a peer.

The second aspect of Vygotsky’s theory is the idea that the potential for cognitive development is limited to a certain extent which he calls the ZPD. The ZPD is the distance between a student’s ability to execute a task under adult guidance and/or with peer teamwork and the student’s ability to solve the problem independently. According to Vygotsky, learning occurs in this zone. The more knowledgeable other or anyone who has a better understanding or a higher ability level than the student with respect to a particular task, process, or concept can help the student. The more knowledgeable other is normally thought of as being a teacher, coach, or older adult, but it can also be peers, a younger person, or even computers.
1.2.1.3 Constructivist Theory of Cognitive Development by Jerome Bruner (1957)

Like Piaget and Vygotsky, Bruner believes that the child has to learn for itself by making sense of its own environment. According to Bruner the outcome of cognitive development is thinking. What we perceive and think is constructed through our mind as a product of symbolic processes. Bruner rejected the idea of stages as popularised by Piaget and to a lesser extent by Vygotsky. He concentrates more on how knowledge is represented and organised as the child develops.

**Modes of representation:** Modes of representation are the way in which information are stored and encoded in memory. Rather than age related stages as given by Piaget, the modes of representation are integrated and loosely sequential. For Bruner, the child will not leave the old way of thinking behind; instead the earlier ways of thinking are used later in life where they can be very useful for some tasks. The modes of representations are enactive, iconic and symbolic modes.

i) **Enactive mode (First year):** This is similar to the first half of Piaget’s sensori-motor stage of development. It involves encoding action based information and storing it in our memory. Thinking is a physical action for the child and knowledge is what the child can manipulate with movements. Thinking about how they do activities or trying to explain them to others in words is practically impossible. The child represents past events through motor responses. As for Piaget, the gaining of object permanence is a major qualitative change in the child’s thinking.

ii) **Iconic (1-6 years):** This is similar to the second half of Piaget’s sensori-motor and preoperational stages of development. Here information is stored visually in the form of images. Drawing is possible for the child. The icons or images are built up from past experiences and based on a number of exposures to similar objects and events. However the child may lack the ability to solve problems.

iii) **Symbolic (6 or 7 years onwards):** This is similar to Piaget’s concrete operational stage of development. Here information is stored in the form of a code
or symbol, such as language, music numbers and so on. The precise timing of the beginning of this capacity depends on the ability of the child. For the first time the child can categorise, think logically and solve problems.

Bruner’s main interest was in the child’s transition from iconic to symbolic modes. According to him cognitive development can be speeded up by training children in the use of symbols. Clearly this runs counter to Piaget who believed progress through these stages was biologically determined. Bruner clearly disagrees with Piaget’s view that the child is isolated and learns on its own. The child works with others to develop its framework for thinking. Bruner also suggests that it is effective when faced with new material to follow a progression from enactive to iconic and to symbolic representation.

Bruner assigns an important role to language in the development of thinking. According to him thinking leads to language but thereafter, language is responsible for the improved development of thinking. Bruner considers learning as an active, social process in which students construct new ideas or concepts based on their current knowledge.

1.2.1.4 The Information Processing Approach to Cognitive Development (1970)

The information processing approach to the study of cognitive development developed out of the American experimental tradition in psychology. The theory is based on the thought that humans process the information they receive, rather than merely respond to stimuli.

Information processing approach compares the mind to a computer, which is responsible for analysing information received from the environment. The approach characterizes thinking as the processes by which the information made available by the environment is transformed into systematic ways. If an individual perceives, storing, encoding, representing or retrieving information to or from his mind, he is said to be thinking. Thinking also includes responding to any limitations on memory processes.

Analysis of stimuli is one of the fundamental assumptions in information processing approach. This is the process by which the encoded stimuli are altered
to suit the brain's cognition and interpretation process to enable decision making. There are four distinct sub-processes that form a favourable association to make the brain arrive at a conclusion regarding the encoded stimuli it has received and kept stored. These four sub-processes are encoding, strategisation, generalisation and automatisation. To solve problems effectively, children must encode critical information about a problem and then use this encoded information and relevant prior knowledge to construct a strategy to deal with the problem.

Like Piaget’s theory of cognitive development, the information-processing approach holds that children play an active role in their own cognitive development. Situational Modification is the process by which an individual uses his experience to handle a similar situation in future. Sometimes, unnecessary and misleading information can confuse the individual and he may show indications of confusion while dealing with a situation which is similar to one he was exposed to before, which he was able to handle successfully. So the nature of the problem should also be taken into consideration while evaluating the individual’s intellectual, problem solving and cognitive insight.

Information processing theory highlights the importance of metacognition. When we put effort into processing information, we turn out to be competent of a metacognitive level of thinking that includes self-awareness, self-inquiry or self-dialogue, self-monitoring and self-regulation of the processes and contents of thoughts, knowledge structures and memories.

1.2.1.5 Theory of Structural Cognitive Modifiability by Feuerstein (1980)

The theory of structural cognitive modifiability suggests that human mental and behavioural structures can be modified as a consequence of exposure to situations that precipitate change. The primary mechanism for creating change is the provision of mediated learning experience. Mediated learning experience is a planned, deliberate, and active process that focuses, interprets, elaborates, and generalizes the learner’s direct experience with the world.

According to Feuerstein’s view, Thinking Skills can be directly taught and learned. To improve the quality of thinking, his philosophy is to focus on what
constitutes deficient cognitive functions. If the learners are provided with tasks that are designed to improve particular thinking skills, their cognitive performance will be improved. He believes that interventional mediation techniques can be used to improve students’ cognitive resources, including flexible thinking to become more socially adaptable and subsequently better life problem solvers.

Feuerstein's Instrumental Enrichment originated in the 1950's. Feuerstein developed a highly successful course for learners with low academic achievement. His intervention was not related to the context of ordinary school learning. Instrumental Enrichment teaches ‘thinking about thinking’ and ‘learning about learning’ rather than precise subject matter. The instruments help the students develop strategies and working habits. Students can apply these strategies in problem solving situations and can generalise rules and principles which can be transferred to a wide range of curricular and extra-curricular domains and contexts. Bridging was also another strong feature of Feuerstein's intervention. During and at the end of each Instrumental Enrichment lesson, the students were persuaded to construct and speak through bridging examples where the principles they have learned and developed in the lesson are applied to situations, within and outside school.

Feuerstein's methodology draws from social psychology, psychometrics and Piaget's theory. He refers to mediated learning experience as being a causative theory of cognitive development. He describes the learning of a child as being facilitated when the culture of the family and his social group is in a state of wellbeing. An important feature is the social interaction between experts, such as parents, teachers - who know more than the learner - and the student. Through ‘mediation’, experts arrange the learning experiences of the students so that they are able to be more independent thinkers and learners. The activities and experiences that the experts present to the learners are named mediated learning experiences.

Piaget’s and Vygotsky's theories on cognitive development lay the groundwork for an array of research studies and developments in the area of
teaching and learning. One of the most influential researches was the work done to accelerate the cognitive development of students and thereby raise the general intellectual capacity. Basis to the question of the possibility of accelerating cognitive development in students, is the argument that development can be changed by environmental effects, such as mental stimulation. The essence of the theory of Structural Cognitive Modifiability that intelligence is changeable and not fixed; also form the basis of these studies.

1.2.2 Cognitive Acceleration Approach (1981)

Cognitive Acceleration is a constructivist approach (CAA) to teaching, designed by Michael Shayer and Philip Adey, to develop students’ thinking ability. It is the process of accelerating students’ ‘natural’ development process through different stages of thinking ability, towards the type of abstract, logical and multivariate thinking which Piaget describes as ‘formal operations’ (Adey, 1999). The work of Piaget, Vygotsky and Feuerstein formed the basis of a theoretical platform of CAA.

The CASE (Cognitive Acceleration through Science Education) programme, established in the early 1980’s by a group - Adey, Shayer and Yates - was designed as an intervention in the science curriculum for students aged between 11 and 14 years. Between 1984 and 1987 the CASE project produced a set of curriculum materials to help students develop the thinking skills required in science. The materials were published as ‘Thinking Science’ a set of 32 activities for average students of age 7, 8 and 9 in England. Since 1989, the CASE project has developed into an extensive pedagogic programme, which has become part of the framework for teaching and learning for many children in U.K. Since the publication of Thinking Science in 1991, it has been adopted in many schools in order to raise the standards in Science. This continuing process has made it possible for longer-term evaluations to be carried out. These evaluations were conducted by the CASE team themselves using assessments of pupil outcomes derived from national assessment frameworks.
In 1996, the CASE team analysed the examination results of about 4,500 students. The analysis showed that for students who had been taught using the CASE approach in 1991 and 1992 there was an increase of 10-20 per cent in the number of those achieving grade C or above in Science, Mathematics and English examinations, compared to control groups. This showed that there is a strong ‘far transfer’ effect. That is, an intervention programme delivered by science teachers through activities with a strong scientific context has produced positive transfer effects on students’ achievement in mathematics and in English literature (Adey, 1999).

Though the approach was first used in a secondary science context, more recent developments have used the approach in Secondary Mathematics (CAME), in technology (CATE), Art, Drama and Music. The approach has also been applied to five to seven year-old children for promoting concrete thinking.

1.2.2.1 The Pillars of Cognitive Acceleration Approach

Cognitive Acceleration lessons are centred on cognitive conflicts which form the basis of CAA. Hence, the theoretical foundation of the CAA is partly Piagetian, with an emphasis on providing conflict situations which encourage equilibration and the construction of the reasoning patterns of formal operations by students themselves. Equal importance is given to Vygotskyian influence, with an emphasis on social construction of reasoning, through metacognitive reflection and carefully managed use of the language of thinking.

Adey and Shayer compiled five features which came to be known as ‘pillars’, and which now form the basis of the cognitive intervention programme. These are (1) concrete preparation (2) cognitive conflict (3) social construction (4) metacognition and (5) bridging

The first pillar is the idea of concrete preparation. We cannot simply present students with a difficult problem and expect the cognitive conflict to do the work of cognitive acceleration. There must be a phase of preparation in which the language of the problem is introduced, along with any apparatus to be used and a context in which the problem is set. The aim is to make sure that the difficulties
encountered are just intellectual and as far as possible are not compounded by problems of language or context.

The second of the five pillars of Cognitive Acceleration theory is cognitive conflict. This occurs when a student encounters a problem which he cannot easily solve for himself, but which, with carefully structured help from an adult or more able peer, he can solve or at least gain the understanding of the nature of the problem so that a solution is more likely to become available later. The principle of cognitive conflict is encapsulated within the idea of a zone of proximal development (ZPD). The ZPD is the difference between what a child can do unaided, and what he can do with the help of an adult. Learning tasks that are well within the child’s capability do not provide the challenge that stimulates cognitive growth. Cognitively stimulating experiences are those which take place within the ZPD or construction zone.

The third pillar is the idea of social construction. The only good learning is that which advances development. The stress here is on the student’s own construction of higher-level forms of thinking. The teacher can provide the appropriate experiences and lead, through cautious questioning, but cannot put higher-level thinking capability directly into the student’s mind. The student must construct this for himself, and it is a slow process.

The fourth pillar is the encouragement of metacognition. Metacognition means simply thinking about one’s own thinking. To take some control of and to become conscious of one’s own thinking is one of the best ways to develop higher-level thinking. In Cognitive Acceleration Approach, students are encouraged to take time to reflect on how they solved a problem, what they found difficult about it, what sort of reasoning they used, how they sought help and what sort of help they needed.

The fifth pillar of CAA is bridging. Bridging is linking of ways of thinking developed in the particular context of the activity to other contexts within science, mathematics or other parts of the curriculum and to experiences in real life. Figure 1.1 illustrates the relationship of these five pillars to one another.
Figure 1.1 The five pillars of Cognitive Acceleration Approach (Adey, 1999)

The relationship of cognitive conflict to construction, shown in Figure 1.1 by a spiral arrow, is not straightforward. When students are presented with a problem with any sort of difficulty in thinking to which they cannot readily produce a solution, they seek simple solutions. They will make a full analysis of the problem in order to reach an accommodation that will meet the immediate needs of the situation. Students on their own will rarely seek full understanding of a situation but will tend to settle for the minimum solution that will meet the immediate demands of the problem in question. Thus cognitive conflict by itself does not automatically lead to reconstruction of concepts or to reaching a full understanding. The cognitive conflict must be solved only by close questioning of the teacher and also through discussion with peer group (Adey, 1999).

1.2.3 The concept of Thinking Skills

Thinking is a covert higher level mental activity. It includes organisation of information and knowledge, manipulation of symbols, comparison, reasoning, evaluation, decision making, judgements and the like. Usually the process of thinking starts when a person faces a problem. Thinking enables him to solve the
problem. It is an activity that proceeds inside the person and hence, an implicit behaviour directed towards arriving at a solution to the problem.

Beyer (1991) considers thinking to be the mental manipulation of sensory input and recalled perceptions (information and thoughts stored in memory) to make or find meaning- to reason about or with, to formulate thoughts, and to judge. Mishra (2008) defines thinking as a higher order covert mental process of cognition characterised by the use of symbols as representation of objects and events and which is directed towards solution of the problem that initiates this higher order process of cognition. Thinking is a mental process that analyses, synthesises a phenomenon, formulates or helps to formulate the solution of a problem, solves or helps to solve the problem, makes a decision, fulfils a desire, searches for meaning, and generates ideas (Passi & Mishra, 2000).

1.2.3.1 Importance of Teaching Thinking Skills

A skill is commonly defined as a practical ability in doing something or succeeding in a task. A thinking skill is a practical ability to think in ways that are judged to be more or less effective or skilled. They are the habits of intelligent behaviour learned through practice. Children can become better at giving reasons and asking questions the more they practice doing so. Thinking skills are processes which, when practiced, empower the brain to work more efficiently (Kagan, 2003).

The key function of education is to teach children to think critically, creatively and effectively (Fisher, 2003). Teaching thinking is strengthened, if thinking is viewed as a collection of component skills rather than a single ability; instruction emphasises the process rather than the product; and teaching takes place within the specific content of an authentic task rather than a general subject (McGregor, 2007).

1.2.3.2 Classification of Thinking Skills

Thinking skills are the mental capacities we use to explore the world, to solve problems and to make judgements. According to Beyer (1991) thinking skills are the distinct, precisely described mental operations used in varying
combinations as we think. To identify every such skill would be to specify all the capacities of the human mind and the list would be endless. However, thinking skills can be categorised such as information-processing, critical thinking, creative thinking, problem solving and metacognition.

Over the years there have been attempts made to develop a classification system for thinking skills. One well known model is the classification of Bloom (1956) which includes knowledge, comprehension, application, analysis, synthesis and evaluation. Quellmalz (1985) also classified thinking skills into five categories as recall, analysis, comparison, inference and evaluation.

Kagan (2003) divides thinking skills into three types: understanding information, manipulating information, and generating information. In each of the three categories specific skills are included. For example, ‘summarise’ is related to understanding information; problem solving is related to manipulating information; and questioning is related to generating information.

Passi, Subhashini and Mishra (2004) followed a product and process approach for the classification of thinking skills.

**Product approach**

Thinking skills are classified on the basis of its output. Accordingly, there can be two categories – critical thinking and creative thinking.

*Critical thinking:* Critical thinking is the process of analysing, synthesising, and evaluating the authenticity and accuracy of information and arguments gathered through observation, experience, reflection and logical reasoning. Passi et al. (2004) identified twenty three micro skills for developing critical thinking. They are comparing, evaluating, hypothesizing, logical deducing, distinguishing similar ideas, distinguishing facts and opinions, classifying, estimating, interpreting, identifying pros, identifying propaganda, justifying, identifying assumptions, observing, predicting, reorganising, inductive reasoning, setting criteria, sequencing, translating, summarising, synthesising and exploring implications.
Creative thinking: It is the process of generating ideas, processes, experiences or objects. The micro skills identified for developing creative thinking are seeing problems, defining problem, making rules, removing faults, enhancing persistency, consider all factors, concept challenge, combination, making decision, focusing, goal setting, imaging, planning, using analogies, finding requirements and elaborating.

Process approach

Passi et al. (2004) arrived at seven families of thinking skills by observing and analyzing the process of thinking. They are focusing, information gathering, organising, analysing, generating, integrating and evaluating skills.

Focusing skills: It is the process of directing one’s attention to selected information. It helps in clarifying problem situation, establishing directions and purposes, and overcoming all external and internal difficulties. The micro-thinking skills which come under this family are defining problem, goal setting, enhancing persistency and focusing.

Information gathering skills: It is the process of acquiring relevant data from various sources. The sources may be experience, literature, people, object or situation. The micro-thinking skills which come under this family are observing, identifying pros and cons, identifying other people’s view, seeing problems, and finding requirements.

Organising skills: It is the process of arranging information so as to be used more effectively. The micro-thinking skills which come under this family are comparing, classifying, sequencing, translating, interpreting, considering all factors and planning.

Analysing skills: It is the process of clarifying existing information by identifying and distinguishing among components, attributes and so on. It involves the sub skills like distinguishing facts and opinion, distinguishing similar ideas, removing faults, using analogies, and concept challenge.
Generating skills: It is the process of using prior knowledge to add new information. It involves the micro-thinking skills like inductive reasoning, logical deducing, predicting, hypothesizing, elaborating, making rules and imaging.

Integrating skills: It is the process of connecting and combining information. The process involves the subskills like summarizing, synthesising, reorganising and combination.

Evaluating skills: It is the process of assessing the reasonableness and quality of ideas. The micro-thinking skills which come under this family are evaluating, making decision, exploring implications, estimating, justifying, identifying assumptions, setting criteria and identifying propaganda.

1.2.4 Attitude

Attitude is a hypothetical construct. It is a favorable or unfavorable evaluative reaction toward something or someone exhibited in ones beliefs, feelings, or intended behaviour (Myers, 1999). Allport (1935) defines attitude as a mental state of readiness, organised through experience, exerting a directive influence upon the individual’s response to all objects and situations with which it is related. In other words, an attitude is nothing more than the way we think, the way we feel, and the way we act toward some situation, concept or another person in our environment.

Attitudes consist of three distinct components: a cognitive component, an affective component and a behavioural component. The cognitive component consists of our beliefs or ideas about the characteristics or attributes of the objects, situation or environment which is generally used by humans in thinking. The affective component reflects emotional response. The behavioural component of attitude is associated with a predisposition to action. However, it is difficult to separate out these three components, as they tend to interact and merge with one another.
1.2.4.1  Learning theory of Attitude by Carl Hovland and Associates (1950)

According to learning theory attitudes are acquired in much the same way as other habits. People learn information and facts about different objects, and they also learn the feelings and values associated with those facts. We acquire information and feelings by the process of association. Attitudes can also be learned through imitation. Message learning is regarded as crucial to attitude change. If a person learns a message, change is likely to follow. Learning theory also suggests that people are persuaded when they transfer an affect from one object to another that is associated with it.

1.2.4.2  Cognitive Dissonance Theory by Leon Festinger (1957)

Dissonance theory deals especially with inconsistencies between people’s attitudes and their behaviour. Relationships among two cognitions can be consonant, dissonant or irrelevant. Cognitive dissonance is the feelings of tension that arise when one is simultaneously aware of two inconsistent cognitions. Dissonance appears to be most consistently aroused when the attitudes and behaviour that are dissonant are important to the self. Cognitive dissonance can be reduced or eliminated only by adding new cognitions, or changing existing ones.

1.2.4.3  Functional theory by Daniel Katz (1960)

Functionalist theory takes the view that attitudes are determined by the functions they serve for us. At the psychological level the reasons for holding or for changing attitudes are found in the functions they perform for the individual, specifically the functions of adjustment, ego defense, value expression and knowledge. Any attitude that is adopted in a person's own self-interest is considered to serve a utilitarian or adjustment function. People adopt attitudes that are rewarding and that help them avoid punishment. Ego-defensive attitudes can be aroused by threats, appeals to hatred and repressed impulses and authoritarian suggestion, and can be changed by removal of threat, catharsis, and self-insight. Expressive attitudes are aroused by cues associated with the individual's values and by the need to reassert his self-image and can be changed by showing the appropriateness of the new or modified beliefs to the self-concept. Knowledge
attitudes provide meaningful, structured environment and bring order and clarity to the complexities of human life.

1.2.5 **Academic Achievement**

Academic Achievement means one’s learning attainment, accomplishments and proficiencies. The term denotes the performance of students, which is determined at the end of a course. According to Baron and Bernard (1962, as cited in Mishra, 2005) the concept of achievement involves the interaction of three factors namely aptitude for learning, readiness for learning and opportunity for learning. Achievement in education implies one’s knowledge, understanding and skills in a specified subject or a group of subjects. Good (1959) defines Academic achievement as the accomplishment or proficiency of performance in a given skill or body of knowledge. The score of students in the final examination can be taken as the performance or achievement score. Knowledge attained or the test score usually designates skill developed during school education or marks obtained which are considered as the academic achievement.

1.2.5.1 **Attribution Theory by B. Weiner**

Attribution theory (Weiner, 1974) is concerned with how individuals interpret events and how this relates to their thinking and behaviour. Heider (1958) was the first to propose a psychological theory of attribution. Attribution theory assumes that people try to determine why people do and what they do. According to him a three-stage process underlies an attribution: (1) the person must perceive or observe the behaviour, (2) then the person must believe that the behaviour was intentionally performed, and (3) then the person must determine if they believe the other person was forced to perform the behaviour, in which case the cause is attributed to the situation or not, in which case the cause is attributed to the other person.

Weiner focused his attribution theory on achievement (Weiner, 1974). He identified ability, effort, task difficulty, and luck as the most important factors affecting attributions for achievement. According to him there is a strong relationship between self-concept and achievement. Causal attributions determine
affective reactions to success and failure. Students with higher ratings of self-esteem and with higher school achievement tend to attribute success to internal, stable, uncontrollable factors such as ability, while they contribute failure to either internal, unstable, controllable factors such as effort, or external uncontrollable factors such as task difficulty (Weiner, 1980).

Attribution theory has been used to explain the difference in motivation between high and low achievers. According to this theory, high achievers will move toward rather than avoid tasks related to succeeding because they believe success is due to high ability and effort which they are confident of. Failure is thought to be caused by bad luck or a poor exam. Thus, failure doesn't affect their self-esteem but success builds pride and confidence. On the other hand, low achievers avoid success-related tasks because they tend to (a) doubt their ability and/or (b) assume success is related to luck or to other factors beyond their control.

1.2.5.2 Achievement Goal theory

Goal Theory is the label used in educational psychology to discuss research on motivation to learn. This theory is devoted to studying the types of goals as well as their impact on multiple facets of learning. Goals of learning are thought to be a key factor influencing the level of a student's intrinsic motivation (Pintrich, 2000).

The achievement goal theory postulates that people can have two predominant dispositional goal orientations in achievement contexts: task orientation and ego orientation. Task orientation is centered on personal success and improvement through effort, while ego orientation is focused on outperforming others and on reaching better results than the rest. A student is described as task-involved when he is interested in the task. This is associated with higher intrinsic motivation. Task-involved students are less threatened by failure because their own ego is not tied up in the success of the task. A student who is ego-involved will be seeking to perform the task to boost one's own ego. Ego-
involved students can become very discouraged in the face of failure, because such failure challenges their self-concept.

1.2.0 Need and Significance of the Study

Science forms a basic part of the human experience. It is a body of knowledge, a way of investigation, a way of thinking and an attitude towards life. The body of scientific knowledge is developed through the process of investigation which is combined with thoughtful reflections guided by critical thinking skills. The nature of science includes development of active enquire, critical thinking, and independent work. Thus science teaching helps in providing opportunities for students to explore the world around them.

Mere learning of scientific ideas and theories will not enable the learner to understand the science concepts. Science education should be based on hands on experiences and generative learning. While handing over the wealth of science to the next generation, it is important to consider the following ideas:

i. Science cannot be viewed as a finished product
ii. The process-oriented method of learning helps the learner construct new forms of knowledge
iii. Concepts and ideas in science that the learner constructs should have linkage with real life situations (KCF, 2007).

Analysing the drawbacks of science education in India, the NFGTS, 2005 remarked that, it must undergo a paradigm shift. Rote learning should be discouraged. Inquiry skills should be supported and strengthened by language, design and quantitative skills. Following are certain major criticisms leveled against the prevailing science education in India.

- There is a belief that the aim of science education is to transmit knowledge that has already been gathered.
- The learning process is neither process-oriented nor learner-centred.
- There is a tendency to promote rote learning of concepts in science to excel in examination and the innate curiosity and scientific temperament of the learner are neglected.
Learning of science fails to become interesting and challenging to the learner.

Science education has yet to become life related (KCF, 2007).

The mismatch between cognitive development of the child and the concepts taught can be reduced and the quality of learning improved if students are taught to think critically. Deep and meaningful science learning involves examining new facts and ideas critically, and tying them into existing cognitive structures. According to Schafersman (1991) people can be influenced through effective science education to think critically on issues related to their personal and professional areas. Development of thinking ability is essential for the students of science as it helps them in their future career and develops positive attitudes essential for building up a progressive minded society (Smitha & Manjula 2011).

Patrick, Leonard, Ernest and Amaury (1995) found that curricular exposure, formal classroom and instructional experiences, and out-of-class experiences influence the development of students' critical thinking skills. So developing a repertoire of thinking processes, which can be applied to solve problems, is one of the major goals of Science Education. Schools should give much greater emphasis on co-curricular and extracurricular elements aimed at stimulating investigative ability, inventiveness and creativity, even if these elements are not part of the external examination system (NFGTS, 2005). Hence teachers have the crucial task of helping their children understand how to think effectively and showing them how they can best use their brain. They have to encourage and accelerate the development of thinking process of their students from concrete to abstract that is to the higher levels of thinking. Higher order thinking refers to Thinking Skills like synthesising, analysing, reasoning, comprehending, applying and evaluating.

Schafersman (1991) observes that many secondary school students do not possess the higher order thinking skills expected of them. Zhou, Wang and Yao (2007) found that high school students’ dispositions to critical thinking skills are
very low. According to Halpern (1992) having only a limited command of thinking skills is one of the reasons for students falling behind in school.

Good thinking is not something that comes naturally. It requires developing strategies, techniques and methods. If we want to teach children to think we should try to improve their problem solving ability. Problem solving appears to offer excellent potential for nurturing thinking skills (McGregor, 2007). Thinking and problem solving abilities are closely related to the intellectual level of the children and their academic achievement.

High quality thinking is not the necessary outcome of usual teaching. Powerful learning environments which develop thinking will be created only when young children are given time and opportunity to discuss their thinking processes. If we can bring the process of thinking and learning to a conscious level and help our children to become more reflective, then we can help them to gain control or mastery over the organisation of their learning (McGregor, 2007). In teaching thinking, it is very important to provide the students with metacognitive strategies or skills like planning for learning, thinking about thinking and evaluating learning. Hamers and Overtoon (1997, as cited in Assaf, 2009) believe that metacognition is necessary for developing higher thinking skills. They point out that students need to think about their thinking before, during and after a task by, activating acquired knowledge, monitoring their own activity and assessing performance and consequences respectively.

Several studies, however, have indicated that improving students’ thinking skills requires more explicit teaching of it. Quitadamo, Faiola, Johnson and Kurtz (2008) observe that community-based inquiry method is effective in improving thinking skills. Prasart and Benjaporn (2009) found inquiry-based teaching increases analytical thinking and learning satisfaction. Suleyman (2005) observes that problem based learning in science teaching is effective in the development of logical thinking skills among the student teachers. Investigations on innovative methods and approaches for improving thinking skills are the requirement of the time.
Attitude is an idea associated with emotion, which predisposes a class of actions to a particular class of social actions (Triandis, 1971). Components of attitudes towards science incorporated on the basis of different research studies includes, the perception of the science teacher, anxiety towards science, the value of science, self-esteem in dealing with science, motivation in learning science, enjoyment of science, attitudes of peers and friends towards science, attitudes of parents towards science, the nature of the classroom environment, achievement in science, and fear of failure on course (Osborne, Simon & Collins 2003).

It has been proven that attitudes towards school subjects influence academic achievement. Even at different ability levels, the increases in achievement were attributed to increments in attitude scores (Marjoribanks, 1976). One of the reasons for the declining trend in pursuing science education at the higher levels is the increasing dissatisfaction of students with teaching of science in the higher classes in school (Shukla, 2005). Expected achievement in science is a factor that is heavily influenced by attitudes toward science learning. Attitude towards Science Learning is not a single unitary construct, but rather consists of a large number of sub constructs all of which contribute in varying proportions towards an individual’s attitudes towards science. Klopfer (1971) categorised a set of affective behaviours in science education as follows:

- the manifestation of favourable attitudes towards science and scientists
- the acceptance of scientific enquiry as a way of thought
- the adoption of ‘scientific attitudes’
- the enjoyment of science learning experiences
- the development of interests in science and science-related activities and
- the development of an interest in pursuing a career in science or science related work.

As would be expected, positive attitudes toward science lead to better results on achievement measures of science capability (Weinburgh, 1998). A student’s attitude toward science is more likely to influence achievement in science than achievement influencing attitude (Schibeci & Riley 1986, as cited in
Craker, 2006). There are research studies which shows favourable attitude can be developed by students by adopting suitable strategies. Raved and Assaraf (2011) found interpersonal interaction between teacher and student, the relevance and authenticity of the topics being studied, and the diversity of the teaching methods as the influential factors underlying the attitudes of high school students towards science studies. Lin et al. (2014) established that a combined teaching method involving Science Magic activities and the 5E Instructional Model is effective for improving students’ attitude toward science. Yakar and Baykara (2014) found that inquiry-based learning practices improved attitude towards science of preservice science teachers. The studies conducted by Ferreira and Trudel (2012) revealed that problem-based learning increase students’ attitude toward science. Kose, Sahin, Ergun and Gezer (2010) investigated the effect of cooperative learning on eighth grade students' achievement and attitude toward science and showed that the students in the experimental group had better performance. Tosun and Senocak (2013) showed that PBL was effective in increasing the attitudes positively toward chemistry of students with weak scientific backgrounds. As attitude is identified as an important contributing factor for achievement and as it can be developed among students through the adoption of appropriate strategies and techniques, those strategies should be needed to be identified and tested which positively influence the advancement of the same.

Achievement is the product of all the educational endeavors. In the present competitive era, the people are judged not only by their personality but also by their achievements in their life. The performance of the people in a class is usually judged by their academic achievements. Chemistry is an important subject containing a number of basic concepts and theories. These concepts and theories are abstract in nature. Therefore students consider Chemistry which forms an integral part of the science curriculum both at the high school as well as the higher secondary level, as a difficult subject. So to improve learning outcomes by changing teaching methods and strategies is a constant need in the field of chemistry education.
Many research studies are conducted to analyse the various factors that influence academic achievement. These factors are meaningful causal thinking (Berkant, 2009) memory capacity and logical thinking (Stamovlasis, 2010), quality of prior knowledge (Hailikari & Nevgi, 2010) and self-concept (Lewis, Shaw, Heitz & Webster, 2009). Mental speed and short-term memory, as ability factors reflecting basic cognitive processes, exert an indirect influence on academic achievement by affecting reasoning and divergent thinking (Vock, Preckel & Holling, 2011).

There are many research evidences which proved that academic achievement in Chemistry can be increased by applying suitable strategies and teaching methods. Some of the strategies and methods tested and verified included jigsaw cooperative learning and computer animation techniques (Karacop & Kemal, 2013), mathetics (Elias, 2009), single inquiry laboratory experience (Cacciatore & Sevian, 2009), conceptual change approach (Atasoy, Akkus & Kadayifci, 2009) and blended learning approach (Williams, Bland & Christie 2008). More research innovations are required in the field of chemistry education in order to improve the learning outcomes of students in specific subject areas in specific contexts.

Thinking is a learned skill that requires instruction and practice. To truly encourage thinking, a teacher must design assignments and exercises that actually use new and novel situations and problems. This will help to improve achievement and attitude of students towards Science Learning processes. Cognitive Acceleration is an innovative learning approach designed to produce long term gains in academic achievement by attempting to raise children's thinking skills and hence intellectual performance. The process of this approach includes maximize cognitive conflict through creating experiences which are puzzling and challenging children's current levels of understanding.

Cognitive Acceleration, a thinking skills approach provides the students the tools for thinking and to be conscious of their own thinking. The cognitive conflict presented before the students is resolved through investigation and discussion. The
whole class share results and experiences, and the teacher facilitate metacognition through a conscious summary of the strategies successfully applied and a naming of the thinking skills used. The studies on Cognitive Acceleration Approach (CAA) (Shayer & Adhami, 2007; Jon & Cathie, 2007; Julie & Dorothy, 2007; Lorna & Trevor, 2007; McCarthy, 2007; McLellan, 2006; Adey, 2002; Backwell & Hamaker, 1998; Adey & Shayer, 1994) showed favourable results in terms of cognitive development, thinking skills, short term and long term gains in academic achievement in science, mathematics, arts and technology and also for the transfer of thinking skills into other curriculum areas. It improves the dynamism of the class and some of the lower attaining children can solve problems much quicker than the higher attaining (Anna, 2008). Students become more confident in attempting to answer questions, writing up investigations, making predictions about experiments, explaining their findings and they achieve better results in problem solving in this programme (Angus, 2001).

However there is no research evidence for the effectiveness of the Cognitive Acceleration Approach (CAA) for improving thinking skills and achievement in different branches of sciences such as Physics, Chemistry and Biology at secondary level. The effectiveness of the CAA on the affective domain variables such as attitude and interest also is not investigated. The Cognitive Acceleration Approach (CAA) has been tested as intervention programme for a long period and never investigated as a normal classroom teaching approach. There is no research evidence for the improvement of thinking skills, other than the formal operational thinking at secondary level through the implementation of the CAA. Moreover the investigator could not find any study related to the approach in the Indian context. Hence the investigator felt that there is a strong need to take up the present study aiming at to test the effectiveness of the Cognitive Acceleration Approach in improving students’ Thinking Skills in Chemistry, Attitude towards Science Learning and Achievement in Chemistry among secondary school students.
1.4.0 Statement of the Problem

The present study is intended to test the effectiveness of the Cognitive Acceleration Approach in improving Thinking Skills in Chemistry, Attitude towards Science Learning and Achievement in Chemistry among the Students of Standard Eight in the Secondary Schools under the Board of Secondary Education of Kerala State. The study is entitled, ‘Effectiveness of Cognitive Acceleration Approach in Improving Thinking Skills, Attitude and Achievement in Chemistry.’

1.5.0 Operational Definitions of the Key Terms

**Effectiveness**

Oxford Dictionary (2008) defines effectiveness as the ‘degree to which something is successful in producing a desired result’. In the present study, effectiveness means, the capability of the Cognitive Acceleration Approach to produce the desired effect in terms of Thinking Skills in Chemistry, Attitude towards Science Learning and Achievement in Chemistry.

**Cognitive Acceleration Approach**

Cognitive Acceleration Approach (CAA) is an innovative teaching approach developed by Adey, Shayer and Yates in the early 1980’s. It was designed as an intervention programme in science curriculum, aims to promote the development of students’ general ability to process information. Cognitive Acceleration is the process of accelerating students’ natural development process through different stages of thinking ability, towards the type of abstract, logical and multivariate thinking (Adey, 1999). CAA involves five steps, namely, Concrete preparation, Cognitive conflict, Social construction, Metacognition and Bridging.

**Thinking Skills in Chemistry**

Thinking Skills refers to the skills which enhance effective learning through thinking. It is a higher order ability to perform complex cognitive tasks smoothly and precisely (McGregor, 2007). In the present study, Thinking Skills in
Chemistry refers to the total score obtained by a student as measured in the test, namely ‘Thinking Skills in Chemistry’, constructed by the investigator on the selected topics in Chemistry namely, physical and chemical changes, elements and compounds, types of solutions, acids and bases, water, and properties of metals, based on the selected components of thinking skills namely, Classifying, Hypothesising, Drawing inference, Justifying, and Interpreting.

**Attitude towards Science Learning**

Comprehensive dictionary of education (Ahmad, 2008) defines Attitude as: a belief and feeling that predisposes one to respond in a particular way to objects, people and events; a learned tendency to respond to people or objects in a positive or negative way; a tendency to respond positively or negatively to other individuals, to institutions or to courses of activity. In the present study Attitude towards Science Learning refers to a predisposition of mind or mindset of an individual which direct him to respond favourably or unfavourably towards the teaching learning activities of science within and outside the classroom. It is measured by the Scale of Attitude towards Science Learning. The components of Attitude towards Science Learning included in the scale were 1) Attitude towards classroom learning 2) Attitude towards science related activities 3) Attitude towards scientists and 4) Attitude towards scientific contributions.

**Achievement in Chemistry**

Dictionary of Education (Good, 1959) defines academic achievement as “the knowledge attained or skills developed in the school subjects, usually determined by test scores or by marks assigned by teachers.” In the present study, Achievement in Chemistry is considered as the total score obtained by a student as measured in the Achievement Test constructed by the investigator, in Chemistry, covering the cognitive domain of the behaviours.

**1.6.0 Variables of the Study**

Variables are the conditions or characteristics that the experimenter manipulates, controls or observes. The details regarding the variables of the study are presented below:-
1.6.1 Independent Variables

The independent variable of the present study was the treatment variable that includes two levels. 1) The instruction based on the Cognitive Acceleration Approach (CAA) given to the experimental group. 2) The instruction based on the existing Activity Oriented Method (AOM) given to the control group.

1.6.2 Dependent Variables

The Dependent Variables of the present study were Thinking Skills in Chemistry, Attitude towards Science Learning and Achievement in Chemistry.

The selected components of Thinking Skills in Chemistry were:

i. Classifying
ii. Hypothesizing
iii. Drawing Inference
iv. Justifying
v. Interpreting

The selected objectives of Achievement in Chemistry were:

i. Remember
ii. Understand
iii. Apply
iv. Analyse
v. Evaluate
vi. Create

1.6.2 Extraneous variable

The investigator selected Intelligence as the extraneous variable for the study, since it may affect Thinking Skills, Attitude towards Science Learning and Achievement in Chemistry irrespective of other learning conditions.
1.7.0 Objectives of the Study

1.7.1 General objective

To find out the effectiveness of the Cognitive Acceleration Approach in teaching Chemistry, with respect to (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry among the students of Standard Eight.

Specific objectives

1. To prepare instructional material based on the Cognitive Acceleration Approach for teaching Chemistry to the students of Standard Eight
2. To prepare and validate the tools, namely a) Test on Thinking Skills in Chemistry to measure Thinking Skills and b) Achievement Test in Chemistry to measure Achievement of the students of Standard Eight
3. To analyse the scores on (a) Intelligence (b) Thinking Skills in Chemistry (c) Attitude towards Science Learning and (d) Achievement in Chemistry of the students in the experimental and control groups
4. To find out the relationship among the scores on Intelligence and the pretest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students in the experimental and control groups
5. To find out whether there is any significant difference between the pretest scores on (a) Intelligence (b) Thinking Skills in Chemistry (c) Attitude towards Science Learning and (d) Achievement in Chemistry of the students in the experimental and control groups
6. To find out whether there is any significant difference between the pretest and posttest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students in the experimental group
7. To find out whether there is any significant difference between the pretest and posttest scores on (a) Thinking Skills in Chemistry (b) Attitude
towards Science Learning and (c) Achievement in Chemistry of the students in the control group

8. To find out whether there is any significant difference between the posttest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students in the experimental and control groups

9. To find out whether there is any significant difference between the gain scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students in the experimental and control groups

10. To find out the effect of Cognitive Acceleration Approach over the Activity Oriented Method on the posttest scores of (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry by controlling the effects of Intelligence and the pretest scores on the dependent variables

11. To find out the effect of Cognitive Acceleration Approach over Activity Oriented Method on the posttest scores of the components of (a) Thinking Skills in Chemistry (b) Achievement in Chemistry by controlling the effects of Intelligence and the pretest scores on the dependent variables

12. To find out whether there is any significant difference between the posttest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students exposed to the Cognitive Acceleration Approach with respect to gender

13. To find out the effect of gender, on the posttest scores of (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students exposed to the Cognitive Acceleration Approach by controlling the effects of Intelligence and the pretest scores on the dependent variables
1.8.0 Hypotheses of the Study

1. There is significant relationship among the scores on Intelligence and the pretest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students in the experimental and control groups

2. There is significant difference between the pretest scores on (a) Intelligence (b) Thinking Skills in Chemistry (c) Attitude towards Science Learning and (d) Achievement in Chemistry of the students in the experimental and control groups

3. There is significant difference between the pretest and posttest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students in the experimental group

4. There is significant difference between the pretest and posttest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students in the control group

5. There is significant difference between the posttest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students in the experimental and control groups

6. There is significant difference between the gain scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry between the students of the experimental and control groups

7. There is significant effect of the Cognitive Acceleration Approach over the Activity Oriented Method on the posttest scores of (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry, by controlling the effects of Intelligence and the pretest scores on the dependent variables
8. There is significant effect of the Cognitive Acceleration Approach over the Activity Oriented Method on the posttest scores of the components of (a) Thinking Skills in Chemistry (b) Achievement in Chemistry by controlling the effects of Intelligence and the pretest scores on the dependent variables.

9. There is significance difference between the posttest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students exposed to the Cognitive Acceleration Approach with respect to gender.

10. There is significant effect of gender, on the posttest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students exposed to the Cognitive Acceleration Approach by controlling the effects of Intelligence and the pretest scores on the dependent variables.

1.9.0 Methodology in Brief

Methodology is the totality of procedures followed by the investigator to make the study significant and valid to the maximum possible extent. In this session, the investigator presents a brief idea about the procedure adopted in the execution of the study.

1.9.1 Method adopted for the Study

The investigator selected the Experimental Method for the present study. The research design selected for the study was the Pretest-Posttest Nonequivalent Groups design, with one experimental group and one control group. The experimental group was taught through Cognitive Acceleration Approach and the control group through the routine method used in schools which follow the curriculum designed by the Board of Secondary Education, Kerala State.

1.9.2 Population and sample of the Study

The population of the study comprised all the students of Standard Eight studying in schools following the curriculum designed by the Board of Secondary Education, Kerala State.
Considering the nature, demands and limitations of the study, the investigator selected Holy Cross Higher Secondary School in Kottayam District, Kerala State for the experimentation. The school had five divisions for Standard Eight each comprising 39 students. The investigator randomly selected two divisions namely VIII D and VIII E as the sample of the study. The investigator then randomly selected one of the intact classes as the experimental group and the other as the control group, each consisting of 39 students. Thus a group of 78 students from two classes was taken as the sample.

1.9.3 Tools used for the Study

In the present study the investigator assessed the effectiveness of the Cognitive Acceleration Approach over Activity Oriented Method with the help of pretests and posttests on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry. For this purpose the investigator used the following tools.

1. Test on Thinking Skills in Chemistry developed by the investigator to assess the Thinking Skills in Chemistry of the students of Standard Eight
2. Scale of Attitude towards Science Learning (SATSL) developed and standardized by Joseph and Suresh (1998) in order to measure the Attitude towards Science Learning of the students of Standard Eight
3. Achievement test in Chemistry developed by the investigator to measure the Achievement test in Chemistry of the students of Standard Eight
4. Raven’s Standard Progressive Matrices (RPM,1996) to measure the level of intelligence of the students in the experimental and control groups

1.9.4 Procedure adopted for the Study

The procedure adopted of the study involved three phases; i) the Pretest phase, ii) the Treatment phase and iii) the Posttest phase. In phase one the investigator randomly selected two intact classes includes 39 students each from the five divisions of Standard Eight from Holy Cross H.S.S. Cherpunkal, Kottayam district, Kerala State. The selected classes were randomly assigned as the experimental and control groups. The investigator, next, administered the test
on Thinking Skills in Chemistry, Scale of Attitude towards Science Learning (SATSL) and Achievement test in Chemistry to both the groups. The scores on intelligence of the two groups were measured by administering the Raven’s Progressive Matrices Test (RPM, 1996).

The second phase of the study was that of the treatment. The experimental group was taught, for three months using the instructional material prepared by the investigator based on Cognitive Acceleration Approach. The control group received instruction through the routine Activity Oriented Method of teaching.

The third phase of the study was the posttest phase. After the treatment the test on Thinking Skills in Chemistry, Scale of Attitude towards Science Learning (SATSL) and Achievement test in Chemistry were again administered to both the experimental and control groups as the posttests.

1.9.5 *Statistical Techniques used*

The investigator used descriptive and inferential statistics for the analysis of the data, collected. Descriptive statistics such as mean, median, mode, standard deviation and skewness were used to analyse the nature of distribution of the pretest and posttest scores on the dependent variables, among the students in the experimental and control groups. The investigator also prepared a frequency distribution table to study the distribution of the scores. Pearson’s Product Moment Coefficient of Correlation $r$ was used to find out the relationship among the scores on Intelligence and the scores on the dependent variables.

The investigator used the inferential statistics (1) Test of significance of correlation, to find out the significance of the relationship among the scores on Intelligence and the scores on the dependent variables (2) Test of significance of difference between the means of two independent groups, to find out the significant difference if any, in the pretest and posttest scores on the dependent variables, between the students in the experimental and control groups, (3) Test of significance of difference between the means of two correlated groups, to find out the significant difference if any, between the pretest and posttest scores on the dependent variables, of the students in the experimental or control groups and (4)
ANCOVA (Analysis of Covariance) and one way MANCOVA (Multivariate Analysis of Covariance) to test the genuineness of the effect of the Cognitive Acceleration Approach on the dependent variables when compared with the existing Activity Oriented Method.

All of the statistical analysis required for the study was done with the help of the SPSS software package (SPSS - version 20.0).

1.10.0 Scope of the Study

The purpose of the present study was to find out the effect of the Cognitive Acceleration Approach over the existing Activity Oriented Method with respect to Thinking Skills in Chemistry, Attitude towards Science Learning and Achievement in Chemistry. Resolving cognitive conflicts through discussion in small groups is the key factor in Cognitive Acceleration. For setting the thinking agenda and developing responses, Cognitive Acceleration creates an atmosphere of questioning among children. It also includes questions to encourage clarification of thought, to construct hypotheses and to consolidate thoughts and views. It will enhance students’ information processing ability by setting cognitive challenges and encourage them to reflect and become more conscious of their own thinking.

The present study will help teachers, parents and all people who are interested in making children learn and think. The present investigation will open doors and paves way for further research in the area of Cognitive Acceleration Approach and teaching of Chemistry. The findings of the study will lead to better ways of teaching-learning process and will help the students to learn with more interest and enthusiasm.

1.11.0 Delimitations of the Study

Though necessary precautions were taken to get a reliable result and to make the study as precise and objective as possible the investigator put certain limitations to the present study. These limitations were:

1. The investigator selected only certain components of Thinking Skills
2. The content selected by the investigator for the instructional material is delimited to only selected portions prescribed in the text book of Standard Eight.

3. The tools used in the study namely Test on Thinking Skills in Chemistry and Achievement Test in Chemistry are prepared by the investigator and validated by experts. However they are not standardised.

1.12.0 Organisation of the Report

The investigator has organised the study under five chapters.

Chapter one is the introductory chapter, which includes background of the study, theoretical framework of the study, need and significance of the study, statement of the problem, operational definitions of the key terms, variables of the study, objectives of the study, hypotheses of the study, methodology in brief, scope of the study, delimitations of the study and organisation of the report and conclusion.

Chapter two deals with the survey of related literature which includes studies related to variables of the present study namely Cognitive Acceleration Approach, Thinking Skills, Attitude towards Science Learning, Achievement in Chemistry and gender influence followed by overview of the studies and a conclusion.

Chapter three is the methodology which is a detailed description about the method adopted for the study. It also includes research design, variables, population, sample, tools used for the study, description of the tools, and preparation of the instructional material, experimentation procedure, statistical techniques used and conclusion.

Chapter four gives the detailed description of analysis and interpretation of the data and findings and discussion of the results of the study. The results of the analysis are made in accordance with the objectives stated and hypotheses formulated.
Chapter five gives a brief summary of the study, conclusions and suggestions which includes major findings, conclusions based on the findings, suggestions for improvement and the suggestions for further research.

**Conclusion**

This chapter has detailed the background of the study, theoretical framework of the study, need and significance of the study, statement of the problem, operational definitions of the key terms, variables of the study, objectives of the study, hypotheses of the study, methodology in brief, scope of the study, delimitations of the study and organisation of the report.

The review of related literature relevant to the present study is presented in the succeeding chapter.