CHAPTER – I

1. THEORETICAL CONCEPTION OF THE STUDY

1.1 OVERVIEW

This chapter describes the theoretical conception of the study and it is presented in nine sections. It begins with an overview. The second section deals with Education. The third and the fourth sections discuss about teaching and learning respectively. The teaching of Mathematics is briefly explained in the fifth section. The sixth and the seventh sections present an elaborate idea about the Co-operative Learning and Critical thinking. The section eight throws light on the details of Problem solving ability in Mathematics and the last section deals with the need and significance of the study.

1.2 EDUCATION :

Education is the creation of a sound mind in a sound body. It is a conducive process which develops man’s individuality in all its aspects-physical, mental, emotional and social. With this all round development, he possesses a responsible, dynamic, resourceful and enterprising strong and good moral character. Education helps him to use all his capacities to develop his own self, his society and his nation. In the words of Abdul Kalam, “Education is one that fosters capacities such as spirit of enquiry, creativity, entrepreneurial and moral leadership, which are central to nation building in a democracy. We need education which develops in our children these capacities and makes them autonomous learners who are self directed and self
controlled” (qtd. in Ravi, 2011). Education is a continuous and purposeful social process by which the innate powers of man are developed, his knowledge and skills are enhanced and his behaviour is changed, and he is made a cultured and civilized citizen. Chakarborty, A.K. (2008) opined, “Education is purposive, conscious or unconscious, psychological, sociological, scientific and philosophical process which brings about the development of an individual to the fullest extent and also the maximum development of society in such a way that both enjoy maximum happiness and prosperity”.

Education not only develops knowledge and skills but also inculcates values, trains the instincts, and fosters the right attitudes and habits. As John Dewey (1916) has rightly remarked, “Education is the development of all those capacities in the individual which will enable him to control his environment and fulfill his possibilities”. According to the National Education Policy (1986), Education provides people with an opportunity to reflect on the critical, social, economic, cultural, moral and spiritual issues facing humanity. It contributes to national development through dissemination of specialized knowledge and skills. It is therefore a crucial factor for survival. The ultimate aim of education is thus to enable the student to project intimation of excellence into his personal, professional and social activities. In order to achieve this goal education should be able to stir sophisticated and creative impulses in the student.
1.3 TEACHING:

The success of educational process depends on a large extent on the teacher who is considered as the backbone of the educational system. In the words of Edmund Amidon (1967), “Teaching is an interactive process primarily involving classroom talk which takes place between teacher and pupils and occurs during definable activities”. Teaching is a system of actions intending to induce learning through interpersonal relationships. According to Louis Rath (1971) “The good teaching is explaining, informing, initiating, directing, administering, unifying the group, giving security, clarifying, diagnosing, learning problems, preparing curriculum material, evaluating, recording, reporting, enriching community activities, organising and arranging classrooms, participating in school activities and in professional development”.

Lal & Malhotra (2008) view that teaching is that process in which the teachers prepare the learners for learning by using different methods, techniques and aids, and create suitable circumstances for learning for them, and assist them in learning. There is no meaning in teaching if the learners do not learn and bring out desirable changes in their behaviour. In short teaching means causing to learn. In the view of Clark (1970), “Teaching is an activity which is designed and performed to produce change in student behaviour”. In the words of John Brubacher (1939), “Teaching is an arrangement and manipulation of a situation in which there are gaps and obstructions which
an individual will seek to overcome and from which he will learn in the course of doing so” (qtd. in Sachdeva, 2008). Gage, N.L. (1965) defines, “Teaching is a form of interpersonal influence aimed at changing the behaviour potential of another person”. Green (1971) states, “Teaching is itself an instance of human action aimed at enhancing the human capacity for action”.

The basis of teaching is love, understanding and care. Freedom should be given to the students in order to express themselves. The teacher is the moving spirit in all this. He is considered a guide and friend who understands the child well. One who has lost the child in himself is totally unfit to undertake the task of educating children.

1.4 LEARNING

The main aim of education, as we know is to produce the desired changes in the behaviour of the children, and when those changes have taken place, we say that the child has learnt. Woodworth (1954) defined learning as the process of acquiring new knowledge and new responses. It is, undoubtedly, right to say that learning is wealth to poor, an honour to rich, an aid to the young and a support and comfort to the aged. Learning may be thought of as a progressive change in behaviour which is associated on the one hand with successive presentations of a situation and on the other hand, with repeated efforts of the individual to react it effectively. In the words of Smith H.P. (1962), “learning is the acquisitions of new behavior or the
strengthening or weakening of old behavior as the result of experience”. Like teaching, learning is also a life long process. Teaching is a social phenomenon whereas learning is a psychological phenomenon. In the words of Crow and Crow (1973), “Learning is the acquisition of habits, knowledge, and attitude. It involves new ways of doing things and it operates on individual attempts to overcome obstacles or to adjust to new situations. It represents progressive change in behaviour. It enables him to satisfy interests to attain goals”. A good teaching means good learning. Teaching and learning are interrelated and interdependent. As is the teacher, so are the students is an important saying. In the words of Green (1971), “There is no learning without teaching and teaching may not be fruitful without learning”. In order to facilitate learning more fruitful, large numbers of learning theories have been developed by psychologists and educationists.

1.5 TEACHING OF MATHEMATICS:

Mathematics is the language in which God has written the universe. Mathematics is the pivot of all civilizations. It enters every walk of life. Our entire civilization depends on the intellectual penetration and utilization of nature, which has its real foundation in the Mathematical Science. Roger Bacon has rightly remarked, “Mathematics is the gate and key of the Sciences… Neglect of Mathematics works injury to all knowledge, since he who is ignorant of it cannot know the other sciences or the things of the world. And, what is worse, men who thus ignorant are unable to perceive
their own ignorance and so do not seek a remedy” (qtd. in Sidhu 2002). National Policy on Education (1986) highlighted, “Mathematics should be visualized as the vehicle to train a child to think, reason, analyse, and articulate logically. Apart from being a specific subject it should be treated as a concomitant to any subject involving analysis and meaning”. Mathematical form of today has more and more new applications for day to day life and the rapid growth of desired applications help to develop more and more new fields of Mathematics. Today, Mathematics holds an important place in schools. Mathematics has its own disciplinary values. In fact, Mathematics is an expression of the human mind, and it reflects the active will, the contemplative reason, and the desire for aesthetic perfection. Its basic elements are logic and intuition, analysis and construction, and generality and individuality.

Mathematics is a creative process, deriving ideas and suggestions from real problems, idealizing and formulating the relevant concepts, posing questions, intuitively deriving possible conclusions and then and only then, proving the hunch or the intuited argument deductively. Mathematics is the only subject whose knowledge develops the habit of hard work, concentration, well organized personality and clarity in the students. Locke has remarked, “Mathematics is a way to settle in the minds of children, a habit of reasoning” (qtd. in Sidhu 2002).

The power of critical thinking, logical reasoning, process of induction,
and generalization, and establishment of relationship between different components can be developed through the teaching of Mathematics. Generally while teaching Mathematics the following principles are to be followed:

i. Make Mathematics realistic and interesting.

ii. Consider the student’s prior knowledge.

iii. Make the Mathematics curriculum socially interactive.

iv. Frame innovative Mathematics projects.

1.5.1 Place of Mathematics in school curriculum

Mathematics occupies an important place in the school curriculum. It has been its important part ever since the beginning of formal education and it continues to be so. Realising its social relevance, Kothari Education Commission (1964–66) suggested, “Science and Mathematics should be taught on a compulsory basis to all pupils as a part of general education during first ten years of schooling”. Also the commission recommended that, “Proper foundation in the knowledge of Mathematics should be laid at the school”. According to the commission the advent of automation and cybernetics in this country marks the beginning of the new scientific industrial revolution and makes it the entire imperative to devote special attention to the study of Mathematics. Modern developments in science and technology require a new habit of original and critical thinking and the foundations of such a habit have to be laid in school Mathematics. Teaching higher secondary school Mathematics should reflect the chief characteristics
such as abstractness, precision, generality and logical nature.

The following are the reasons for keeping Mathematics in the school curriculum:

(i) It is the basis of all sciences.

(ii) It is correlated to other subjects and human life.

(iii) It generates logical attitude.

(iv) It provides a definite way of thinking.

(v) It provides opportunity to develop mental abilities of the child.

1.5.2 Objectives of teaching Mathematics at Higher secondary level:

National Policy on Education (1986) put forth the following objectives of teaching Mathematics at Higher secondary level:

i. To develop understanding about the inter-relationship of Mathematical facts, formulae, principles and processes.

ii. To develop understanding of the theoretical and abstract aspects of Mathematics.

iii. To develop skill in solving the same problem by various possible methods.

iv. To learn the application of Mathematics in man’s day-to-day, social, vocational, occupational, and recreational life.

v. To gain confidence and competence in the learning of Mathematics.

vi. To develop logical thinking, reasoning power, analytical thinking, and
critical thinking.

vii. To develop skill in using higher geometrical instruments and field work.
viii. To provide, thorough Mathematical ideas, aesthetic and intellectual enjoyment and satisfaction and to give an opportunity for creative expression.

1.5.3 Mathematics and problem solving ability:

Problem solving is an important component of Mathematics because students would be able to achieve all the three values namely functional, logical and aesthetic. The main objective of teaching Mathematics is to train up the students in the art of problem solving. Problem solving in Mathematics is helpful in the proper development of one’s mental powers. Every problem in Mathematics trains an individual in scientific method of reasoning and thinking. The habit of thinking and problem solving developed by the study of Mathematics helps in establishing an intelligent and good understanding of our surroundings and in the development of some common abilities like arithmetic reasoning, numerical ability and logical reasoning which are very much essential for the day to day life situations. Mathematics is an essential discipline because of its practical role to the individual and society. Presenting a problem and developing the skills needed to solve that problem is more motivational than teaching the skills without a context.

The National Council of Teachers of Mathematics (NCTM, 2000) has recommended that the Mathematics curriculum should focus on the following:

i. Developing skills and applying these skills to handle real life
problems.

ii. Gathering, organizing, interpreting and communicating information.

iii. Developing curiosity, confidence and open mindedness.

iv. Formulating key questions, analyzing and conceptualizing problems, defining problems and goals, discovering patterns and similarities, seeking out appropriate data, experimenting transferring skills and strategies to new situations.

1.5.4 Approaches of teaching Mathematics

An approach is a way of arriving at a solution by the use of logical reasoning. It is precisely what it indicates. It is a means of working through a situation, be that a programme, project, issue, risk or pretty much anything. This may involve the use of methodologies either individually, grouped or cherry picked. There are various approaches of teaching Mathematics. Broadly speaking they are teacher centered and learner centered.

Fischer and Fischer (1987) have identified seven styles of teaching Mathematics. They are as follows:

i. Child centered style:

Here the teacher provides a structure and the students pursue it according to their interests and liking.

ii. Teacher centered style:

In this, the teacher plays a dominant role. The teaching learning
process is determined by the teacher. Learners are passive listeners.

iii. Subject Centered style:

Here, the main focus of the teacher is on the organized contents of the subject matter to be presented to the learners.

iv. Task Centered Style:

The teacher prescribes the material to be learnt by the learners and then he expects specific performance on the part of the students. Here learning is seen on individual bases.

v. Learning Centered Style:

Unlike child centered and subject centered styles, here the emphasis is on the learners and their learning irrespective of their abilities and disabilities.

vi. Co-operative Planner Style:

Means and ends of instructions are prepared by the teacher in cooperation with the learners. Here the teacher encourages and supports the learners in every way.

vii. Emotional Involvement Style.

In this style of teaching the teacher is emotionally involved. He enters the teaching learning process with zeal and dedication and thus he succeeds in producing good class room environment.

1.6 CO-OPERATIVE LEARNING.

Learning is social, sharing and caring and these are the main aims of
learning. One of the four aspects of the pillars of learning is to live together. Our class room teaching must develop the students to realize the importance of living together. Co-operative learning approach (which comes under social interaction family) is one such approach, in which small teams each with students of different levels of ability, use a variety of learning activities to improve their understanding of a subject. Each member of a team is responsible not only for learning what is taught but also for helping teammates learn, thus creating an atmosphere of achievement.

According to Mandal (2009), “A Co-operative class room increasingly emphasizes mediated learning, mediation as facilitating, modelling and coaching. Facilitating involves creating rich environment and activities for linking new knowledge to prior knowledge, problem solving and authentic learning tasks. Coaching involves providing feedbacks, redirecting students’ efforts and helping their use of strategy”. Kagan, (1992) viewed, “Co-operative learning is an instructional strategy based on the human instinct of co-operation. It is the utilization of the psychological aspect of co-operation and competition for student’s learning”. The idea behind the co-operative learning approach is that when the group rather than the individuals are rewarded, students will be motivated to help one another to master academic materials. In the words of Smith, et.al. (2005), “Co-operative learning is a structured process in which team members work towards accomplishing a common goal stressing positive interdependence,
individual accountability and group accountability”.

1.6.1 The development of co-operative learning.

Co-operative learning is an old concept. In the first century Talmud and Quintillion argued that learning could be benefited from teaching one another. The Roman Philosopher Seneca advocated that when we teach, we learn twice. Johann Amos Comenius states that the students would benefit both by teaching and being taught by other students. In the late 1700s Joseph Lancaster and Andrew Bell made extensive use of co-operative learning groups in England and brought it to America. In 1930’s John Dewey promoted the use of co-operative learning groups as part of his famous project method of instruction. He laid emphasis on education as a means of teaching citizens the ways to live co-operatively so as to deserve a democratic society. A structured view of co-operative learning was put forward by Cooper et.al. Recently, interest has been renewed in research on the co-operative learning models. Sophisticated research proceedings used by three groups of researchers, viz. Johnson and Johnson (1979, 1981), Robert Slavin (1983), and Shalom Sharon (1980) have implications for the entire family of methods of co-operative learning approach.

1.6.2 Meaning of Co-operative learning.

Johnson and Johnson (1995) defined, “Co-operative learning is an instructional strategy in which students work together and use their skills for the success of each member of the group”. Most probably it is the instructional
use of small group activities to maximize individual and group learning. The idea is to reduce competition or individualistic experiences by creating supportive and safe group learning experiences. Thus co-operative learning fosters a collaborative atmosphere. Johnson, et.al. (1993) and Slavin, (1995) remark that Co-operative learning has also been associated with greater social and personal development, equal and active participation in the group process and increases the level of aspiration, self esteem, problem solving skills and overall academic development. Johnson, Johnson (1987) found that working co-operatively students completed tasks more accurately and quickly than doing as individual tasks. “By working in teams, the students were able to learn to socially negotiate with one another and learn from each other to achieve their common goal, thus providing evidence that learning is social activity” says Vygotsky (1978). According to Archer Kath, Johnson and Johnson (1994), students were able to enhance team work skill and improve their leadership skills, communication skills and interpersonal skills through presentations and in dealing with their team mates.

Co-operative learning has been shown to be effective for developing rich content knowledge, students’ higher level thinking strategies and abilities to work independently. It provides situations for students to teach each other. When students explain and teach concepts to each other, retention of these concepts improves. There is a strong correlation between the ways we learn and the retention of the material learned. The rate of retention in co-
operative learning is shown in the following figure:

![Learning Pyramid](image)

**Fig 1.1**

Slavin (1995) opined, “Co-operative learning promotes student motivation, encourages group processes, fosters social and academic interaction among students and rewards successful group participation”. In the academic side, co-operative learning promotes critical thinking skills, efficiency in learning and motivation that involves students actively in the learning process. Also class room results are improved, and the problem solving abilities are increased. According to Robert (2000), “In the social context it develops a social support system, less threatening learning environment, good attitude towards school, good relationship, and regular attendance, builds diversity and understanding among students and staff, and establishes a positive atmosphere for modelling and practicing co-operation. Psychologically student centered instruction increases students’ self esteem, co-operation, and self efficacy and develops positive attitudes towards teachers and reduces anxiety”.

Kewley (1998) viewed that “Peer collaboration encourages maximum
student participation at the idea level, resulting in more flexible thinking, multiple solutions and a clearer understanding of the steps of those solutions. Armstrong Melser (1999) concluded that gifted, average and low performing learners experienced a comparable increase in achievement after working together, with gifted group performing only slightly higher. Moore (1998) views that cooperative learning mostly aims at the development of cognition, which includes thinking, remembering, concept formation, problem solving and logical reasoning.

1.6.3 Theories underlying co-operative learning approach

Co-operative learning strategy is based on many theories namely, Constructivism, Social interdependence, Cognitive development, Behavioral learning, Cognitive socio-cultural theories, Andragogy theory and Elaboration theory.

i. Cognitive Socio-Cultural theory

Vygotsky (1978) in his Cognitive socio-cultural theory, viewed learners as culturally and historically situated rather than isolated individuals. Accordingly, he focused his attention on the importance of social context for learning. To highlight the importance of social interaction, he opines. “Any higher mental function was external and social before it was internal. It was once a social relationship between two people. We can formulate the general genetic, law of cultural development in the following way. Any function appears twice, or on two planes. It appears first between the people as an inter psychological category, and then within the child as an intra psychological category”.
According to him all good learning was that which was in advance of development and involved the acquisition of skills just beyond the student’s grasp. Such learning occurred through interaction within the student’s Zone of Proximal development. He defined the ‘Zone’ of his theory as the distance between the actual developmental level the child can have without the help of others and the proximal level the development a child can do in co-operation with others. He believed that scaffolding or mediated learning brings the opportunities for the individual to proactively learn from others and receive their help in mutual interactions, in order to construct new knowledge.

ii. Socio – cognitive theory

Piaget’s theory suggested that cognitive development leads to learning. Piagetian perspectives suggest that when individuals work together, socio-cognitive conflict occurs and creates cognitive disequilibrium that stimulates perspective thinking ability and reasoning. A central component of his development theory of learning and thinking was that both involve the participation of the learner. Knowledge is not merely transmitted verbally but must be constructed and reconstructed by the learner.

iii. Bandura’s Social learning theory

Bandura’s theory (1977) emphasized the importance of observing and modelling the behaviors, attitudes and emotional reactions of others. His theory also explained human behaviour in terms of continuous reciprocal interactions between cognitive, behavioural and environmental influences. In
co-operative learning the learners learn in a group and while doing so, the above social behaviors develop among the learner.

iv. Constructivism

Being student - centered by nature, co-operative learning owed much credit to constructivism. “A major theme in constructivism was that learning was an active process in which learners constructed new ideas or concepts based upon their current / past knowledge” says Bruner (1969). Learners actively constructed knowledge and connected it to previously assimilated knowledge, and made it theirs by constructing their own interpretation. According to Brooks and Brooks, (2001), “situations wherein learners have the opportunities for mutual interactions contribute to learning more effectively. Such learning together situations bring with them opportunities for participants both to explain and to receive explanations and thus reflect on reactions and perspectives of their counterparts”. These conditions are believed to be conducive to a deeper level of understanding which in turn, results in cognitive growth also.

v. Social Interdependence theory

Johnson, and Johnson (1995) view that, Social interdependence theory refers to students’ efforts to achieve, develop positive relationships, adjust psychologically and show social competence. These theorists believed that co-operation is based on intrinsic motivation induced by interpersonal components, with a collaborative desire to achieve, being central towards
achieving co-operative goals.
vi. Behavioural learning theory

Johnson, and Johnson and Holubec (1998) say, “Behavioural learning theory advocates learning can be attained by a reward and reinforcement. Contributors of behavioural learning theory presuppose that co-operative efforts are influenced by extrinsic motivation to achieve group rewards and positive reinforcement”. Reward acts as stimulus for learners to commit to solve the problems.

vii. Andragogy theory

Knowle’s (1984) theory of Andragogy believed that “all learners have natural potentials for learning in non-threatening and student centered learning environments in which they do not experience excessive intervention and control of the teacher” (qtd. in Hosseini, 2008). From the point of his theory, learners should be appreciated as whole persons. Teachers should not only inform them of what they are supposed to learn, but also explain to them the rationale behind what they are to learn.

viii. Elaboration theory

According to Elaboration theory, learners learn more effectively when they try to make someone else understand their intentions by providing explanations and articulation of their ideas. Slavin (2005), has asserted that when learners discuss to find a solution to a problem on a topic, they verbalize their thought and this verbalization plays a critical role in learning and achievement as it elicits elaborative cognitive process. In such situations
the new information is easily related to the old information already present in their memories.

1.6.4 Co-operative learning methods

Davidson & Kroll (1991) opined that Co-operative learning takes place in a setting where students share ideas and work collaboratively in small groups to complete academic tasks. Some of the Co-operative learning method are given below.

Student Teams Achievement Division (STAD)

It was introduced by Robert Slavin and his associates in 1983. According to them the whole class is divided into different groups with four to five members to master content material. Subsequently each student takes a quiz on that learned material and the team’s overall score is determined by the extent to which each student has improved over his or her past performance.

Jigsaw I & II

It was first introduced by Elliot Aronson, Stephen, Sikes, Blaney and Snapp in 1977. It was later modified by Slavin in 1983. The whole class is divided into base groups with four to six heterogeneous members. Individual members of base or home groups are then given separate parts of whole academic textual material. Having learnt something about their parts in their home teams, team members who have the similar parts for learning come together in expert or study groups to study, discuss, and refine their
understanding of their shared parts. After that they return to their home
groups and take turns to teach what they learnt to their teammates. Teams are
evaluated by the sum of their members’ scores on quizzes and tests which they take individually.

**Team Games Tournament (TGT)**

Scholars like Devries, Edwards and Slavin (1978) developed TGT. The procedures are similar to those in STAD. Instead of taking quizzes, the student plays academic games with other members of the class whose past performance was similar to his own. Team members are motivated enough to do their best not only to master the material for their own sake, but also to help others to ensure that everyone learns the lesson or complete the task assigned by the teachers. Teams are evaluated how they have done in comparison with their same level opponents in other teams. The sum of team members’ grades will stand for the team. TGT’s evaluating system is more focused upon posing individual accountability.

**Team Assisted Individualization (TAI)**

Developed by Slavin, Levey & Madden (1986), this is the combination of team learning and individualized instruction. Students are grouped as in STAD and TGT. Students’ test scores and the number of tests they can complete in a week go into a team score and team members receive certificates for exceeding pre set team standards.
**Group investigation**

This was developed by Sharon and Sharon (1992). Students have the choice of deciding their team members, to work co-operatively for completing their group projects, and thereby achieving their shared goals. After each individual finishes his or her task, the group produces a group report. When the task is completed each group presents its report to the rest of the class and final presentation is evaluated by the teacher.

**Circles of learning**

The teacher divides the class into heterogeneous groups of two to six members. Students in each group can sit in a circle and face one another. The subject matter is distributed to each group. Students are responsible for sharing material and information and helping one another to learn. If all members reach an assigned goal, the group would be rewarded. (Johnson and Johnson and Holubec, 1986).

**Small group discovery method**

This was developed by Davidson (1989). This approach is one of guided discovery where students are introduced to thought – provoking topics as problems for investigation. Students are divided into small groups and the teacher’s role is to facilitate activities by asking questions, checking progress and providing assistance. Students are encouraged to talk and listen and solutions to problems are developed in a co-operative atmosphere.
Co-operative integrated reading and composition (CIRC).

Slavin, Levey & Madden (1986), have developed CIRC which is a comprehensive program for teaching, reading and writing language arts. It has been designed for improving the skills of reading and writing. Here, the students of different groups have discussion on a topic, read silently and note down the vocabulary. Then they discuss with their team mates the unknown vocabulary and answer related questions. Students are evaluated based on their improvement in individual achievements, and are calculated as team score.

Constructive controversy (CC).

Developed by Johnson and Johnson (1979), it focuses on the positive influences of planned and structured controversy on achievement and social relationships of participants. In this method, students are supplied with well documented portions and some further references. In each session, the teacher introduces a challenging, hot and interesting topic which demands and arouses for and against oriented discussions.

Learning together (LT)

It was developed by Johnson and Johnson, (1987). In this method class members, mostly heterogeneous groups of three to six students, work together towards certain shared learning goals. This method puts on cross team sharing and learning. The focus is on the actual co-operation and getting along together in the group, which is considered as a necessary part of group
learning. While evaluating, all team members receive the same grade regardless of difference in their contribution to the success of the group.

**Reciprocal teaching and reading (RTR)**

RTR lays the emphasis on strategy training in reading courses. Students in their heterogeneous teams are mostly focused on specific reading comprehension strategies such as predicting, summarizing, questioning and classification of unfamiliar texts, which increase their metacognition abilities. As regards teaching a text, the teacher first activates student’s minds on the topic through different techniques and then introduces the text. Through this technique students will learn the target strategies that the teacher has already planned to teach. Students are then given the opportunity to try to follow the same procedure for the next paragraphs in their teams so as to master the strategies.

**1.6.5 Strategies and techniques in Co-operative learning**

The term strategy refers to patterns of acts that serve to attain certain outcomes and guard against certain others. It may include different techniques of teaching. Techniques are such aids which are used to make the lesson interesting, to explain the content and to remember it by heart during teaching-learning process. Hence, teaching strategies and techniques are used in order to make the teaching effective, successful and interesting. The following are some of the strategies and techniques in Co-operative learning.
**Think – Pair -share**

This is a simple and quick technique. It involves a three step co-operative structure. During the first step individuals think silently about a question posed by the instructor. Individuals pair up during the second step and share their ideas and thoughts with a partner. This task gives them opportunity to collect and organize their thoughts. Pair and share components encourage learners to compare and contrast their understanding with those of another. In the third step, the pairs share their responses with other pairs, other teams or the entire group.

**Three step interview**

Each member of a team chooses another member to be a partner. As a first step, individuals interview their partners by asking and clarifying questions. In the second step, partners reverse their roles. Finally, the members share their partner’s response with the team.

**Round Robin Brain storming**

Class is divided into small groups (4 to 6) with one person appointed as the recorder. A question is posed with many answers and students are given time to think and generate ideas. Then the members of the team share responses with one another in round robin style. The recorder writes down the answers of the group members. This technique helps in generating many ideas because all students participate actively.
Three minute review

Teachers stop any time during a lecture or discussion and give teams three minutes to review what has been said and to ask, clarify questions or answer questions.

Numbered heads

Teams of four each are established. Each member is given numbers of 1,2,3,4. Questions are asked to the group. Groups work together to answer the question so that all can verbally answer the question. Teacher calls out a number (two) and each two is asked to give the answer.

Team pair solo

Students do problems first as a team, then with a partner and finally on their own. It is designed to motivate students to tackle and succeed at problems which initially are beyond their ability. Students can do more things with help (mediation) than they can do alone. By allowing them to work on problems they could not do alone, first as team and then with a partner, they progress to a point they can do alone.

Circle the sage

First the teacher pulls the class to see which students have a special knowledge to share. Those students (the sages) stand and spread out in the room. The teacher then makes the rest of the classmates each surround a sage, with no two members of the same team going to the same sage. The sages explain what they know while the classmates listen, ask questions, and
take notes. All students then return to their teams. Each in turn explains what they learned.

**Partners**

The class is divided into teams of four. Partners move to one side of the room. Half of each team is given an assignment to master, to be able to teach the other half. Partners work to learn and can consult with other partners working on the same material. Teams go back together with each set of partners teaching the other set. Partners quiz and tutor team mates.

**Buzz groups**

Buzz groups are teams of four to six students that are formed quickly and extemporaneously. They discuss on a particular topic or different topics allotted to them. The discussion is informal and they exchange the idea. Buzz groups serve as a warm up to whole class discussion.

**Talking chips**

In talking chips, students participate in a group discussion, surrendering a token each time they speak. This technique ensures equitable participation by regulating how often each group member is allowed to participate.

**1.6.6 Basic elements of co-operative learning**

Dewey (1971) says, “The primary business of school is to train children in co-operative and mutually helpful living”. Putting students into groups to learn is not the same thing as structuring co-operation among students. Co-operation is not:
having students sit side by side at the same table and talk with each other as they do their individual assignments.

(ii) having students do a task individually with instruction that the ones who finish first are to help the slower students.

(iii) assigning a report to a group where one student does all the work and others put their name on it.

According to Johnson and Johnson, (1989); Johnson and Johnson and Holubec, (1993), “Co-operative learning is an instruction that involves students working in teams to accomplish a common goal, under the conditions that include the following elements:

(i) Positive interdependence

The heart of the co-operative learning is positive interdependence. Students must believe that they are linked with others in a way that one cannot succeed without the other member of the group. Students must perceive that they are responsible for their own learning and for the learning of others in the group. They “sink or swim together” says Johnson and Johnson, (1987). This can be fostered through group product, goal independence, learning goal interdependence, role interdependence, reward interdependence, resource interdependence or a task interdependence. Positive interdependence clearly establishes the following:

(i) Each group member has a unique contribution to make to the joint effort because of his or her resources and task responsibilities. It is developed
through setting mutual goals.

(ii) Face to face verbal interaction is referred to the physical set up of the group.

(ii) **Face to face promotive interaction**

Johnson and Johnson (1987) viewed, this element is made necessary by the existence of positive interdependence. Students interact to help each other accomplish the task and promote each other’s success. This process involves interaction among the students, discussion with each other, sharing resources, teaching their knowledge to classmates, helping, encouraging and supporting each other’s efforts to learn and challenging of each other’s reasoning.

(iii) **Individual accountability**

All students in a group are held accountable for doing their share of the work and for mastery of all of the material to be learned. “The performance of each individual student is assessed and the results are given back to the individual and perhaps to the group” says Johnson & Johnson, (1989). Individual accountability can be enhanced by conducting exam to each student, calling on individual to present their group answer, asking questions while monitoring group work and by teaching a small portion to group members.

(iv) **Interpersonal and small group skills**

Slavin (1995) viewed, this is an effective element of co-operative learning. Learners should be motivated to use social skills for high co-
operation. Students should develop leadership, decision making, trust-building, articulating ideas, listening to others, leading and contributing to group dynamics, communication and conflict management skills. In this task teacher must try to teach the social skills through various activities.

**Group processing**

Group processing exists when group members discuss how well they are achieving their goals and maintaining effective working relationships. (Johnson & Johnson, 1987). A common procedure for group processing is to ask each group to list at least three things the group did well and at least one thing that could be improved. Such processing enables learning groups to focus on group maintenance, facilitates the learning of social skills, ensures that members receive feedback on their participation and reminds students to practice collaborative skill consistently.

**Equal opportunities for success**

All students have an opportunity to contribute to their team. Success depends on the joint efforts of everyone to achieve mutual goals. All students have the commitment to the common good. Individual’s work contributes not only to his own well being but also to the well being of all other collaborators. There is a built in concern for the common good and the success of others, as the efforts of others also contribute to one’s own well being.

**Group heterogeneity**

The size of co-operative learning groups is relatively small and heterogeneous. The recommended size is usually three to five students.
Heterogeneous groups are formed in terms of skills, levels, interests and role assignment. Also groups should contain both males and females.

1.6.7 Characteristics of co-operative learning

i. Co-operative learning task is designed based on shared learning goals and outcomes

ii. Co-operative behaviour involves trust building activities, joint planning and an understanding of team support and conduct.

iii. It develops group work skills – explicit teaching, and small group team building exercises.

iv. The teacher should always monitor group activity and answers student’s questions and guides discussion.

v. Individual and group assessment is done in all activities.

1.6.8 Advantages of co-operative learning

(i) Co-operative learning develops higher levels of thinking skills.

(ii) Skill building and practice can be enhanced and made less tedious through co-operative learning activities in and out of the classroom.

(iii) It creates an environment for active, involved and exploratory learning.

(iv) It improves the performance of the weaker students when grouped with high achieving students.

(v) It addresses learning style differences among students.
(vi) It promotes student learning and academic achievement.
It increases student retention.
(vii) It enhances student satisfaction with their learning experiences.
(viii) It helps students develop skill in oral communication.
(ix) It develops students’ social skills
(x) It promotes students self esteem.

1.6.9 Jigsaw Method

Jigsaw method of co-operative learning strategy is used in the present study. This method has been used for over thirty years. It was developed by Elliot Aronson and his graduate students in 1977. It was later modified by Slavin in 1986. The idea behind this Jigsaw method is just same as Jigsaw puzzle, each piece - each student’s part. “If each student’s part is essential, then each student is essential” says Aronson, (2000).

The Jigsaw strategy is a co-operative learning technique appropriate for students between 3rd to 12th grades. This strategy is an efficient way of presenting the teaching material and it also encourages listening, engagement, interaction, teaching and co-operation by giving each member of the groups an essential part to play the academic activity.

The strategy involves breaking the classroom into small groups of four to six students. Each group is responsible for a specific piece of knowledge that they will discuss with other classmates as shown in the following figure:
1.6.10 Implementation Steps (Aronson 2008)

i. Students are divided into 5 or 6 members in Jigsaw group, known as base group. The group should be diverse in terms of ethnicity, gender, ability and race.

ii. The day’s lesson is divided into 5-6 segments; each student is assigned one segment to learn. Students need to have direct access only to their own segment.

iii. Students should be given time to read over their segment at least twice to become familiar with it.

iv. Each student meets with the members of the other groups who have the same assigned content and they form an expert group.

v. The expert group learns the material together, shares what information
they have learned, listens carefully, takes notes and then they take turns practicing how they will present that information to their base group.

vi. After an appropriate amount of time, the students regroup with their original groups; one by one they teach the other members what they have learned. Other members are encouraged to listen carefully and ask questions in order to ensure mastery of the material.

vii. The teacher observes each group and act as a facilitator, helping poor, quieter students and intervening when students are too talkative and monopolizing.

viii. A quiz or test on the materials is given in the end, so as to make sure that they have attained mastery over the content.

1.6.11 Advantages of jigsaw method

i. An efficient way to learn the material.

ii. Builds up a deep knowledge.

iii. Develops team work and co-operative working skills.

iv. Builds on conceptual understanding.

v. Facilitates interaction among students.

vi. Encourages active participation.

vii. By sharing and enhancing information in this way, students learn to appreciate and value each other’s opinions.

viii. Enables lower level students to learn from others in their expert groups.

ix. Builds up interpersonal and interactive skills.

x. Students are held accountable among their peers.
1.7 CRITICAL THINKING

According to Facione (1986), “Critical thinking is the ability to properly construct and evaluate arguments” Thinking is a natural process. “The main goal of education is what to think and how to think but left to itself, it is often biased, distorted, partial, uninformed and potentially prejudiced; excellence in thought must be cultivated” says Seriven and Paul, (2004). Critical thinking is, very simply stated, the ability to analyze and evaluate information. Norris (1985) declared, “critical thinking is deciding rationally what to or what not to believe”. Elder and Paul (1994) suggested, “critical thinking is best understood as the ability of thinkers to take charge of their own thinking”. In fact, Critical thinking is a rich concept that has been developing throughout the past 2500 years.

There are many variations on the definition of critical thinking. Some consider the concept as a product, an end result, critical thought and the process. Often the concept is limited to logic, reasoning skills and problem solving. Watson and Glaser (1994) view critical thinking as, “a composite of attitudes, knowledge and skills. This composite includes attitudes of inquiry that involve an ability to recognize the existence of problems and an acceptance of the general need for evidence in support of what is asserted to be true; knowledge of the nature of valid inferences, abstractions, and generalizations in which the weight or accuracy of different kinds of evidence are logically determined; and skills employing and applying the
above attitudes and knowledge”. Ennis (1985) remarked, “Critical thinking is
reflective and reasonable thinking that is focused on deciding what to believe
or do. It includes creative activities such as formulating hypotheses,
questions, alternatives and planning for experiments”. He developed the
following disposition about critical thinking:

i.  Seek a clear statement of the question.

ii.  Seek reasons.

iii.  Try to be well informed.

iv.  Use credible sources and mention them.

v.  Take into account the whole situation.

vi.  Try to remain relevant to the main point.

vii.  Keep in mind the original.

viii.  Look for alternatives.

ix.  Be open minded.

x.  Take a position (and change a position) when the evidence and
reasons are sufficient to do so.

xi.  Seek as much precisions as the subject permits.

xii.  Deal in an orderly manner with the parts of a complex whole.

xiii.  Be sensitive to the feelings, level of knowledge, and degree of
sophistication of others.

BrookField (1987) defines, “critical thinking as a productive,
positive, emotive and rational process that occurs in contextually specific
events triggered by both positive and negative life events”. He hypothesizes the following four components of the process of critical thinking:

i. Identifying and challenging assumptions,

ii. Challenging the importance of the context,

iii. Imagining and exploring alternatives and

iv. Reflective skepticism.

The National Council for Excellence in Critical Thinking Instruction (2006) defines critical thinking as, “that mode of thinking – about any subject, content, or problem in which the thinker improves the quality of his or her thinking by skillfully taking charge of the structures inherent in thinking and imposing intellectual standards upon them and is closely related to educational goals to create lifelong learners because critical thinking is a skill that is applied across multiple subjects”

Critical thinking is self directed, self disciplined, self monitored and self corrective thinking. It presupposes assent to rigorous standards of excellence and mindful command of their use. It entails effective communication and problem solving abilities as well as commitment to overcome our native egocentrism and sociocentrism. A critical thinker improves the quality of his or her thinking by skillfully analysing, assessing and reconstructing it.

Paul (2006) remarked, “Critical thinking is inherently linked to effective learning. Being able to think about what one is learning while
interpreting and making relations is an important part of the learning process”. Kurfiss (1988), Tsui (1999) are of the view that critical thinking skills allow students to more quickly assimilate subject – specific course content and also provide a framework that allows students to engage and respond to less well defined problems. As a result, students are better prepared to confront both personal and professional challenges.

Critical thinking is a form of problem solving that is much more than just gaining knowledge. Someone who has good critical thinking skills will look at both sides of an argument, and they will also look at evidence to support the two arguments. In addition to this they will break down the arguments and looking at the implications which are connected to them. Once they have done this they will look for contradictions. The side that has the least amount of contradictions will be supported, while the side that has the most contradictions will be discarded.

“Critical thinking occurs when students construct meaning by interpreting, analyzing and manipulating information in response to a problem or question that requires more than a direct, one right answer application of previously learned knowledge” says Adams (1994). This can be characterized by specific core thinking skills, which can be developed in the classroom through instruction and guided practice.
1.7.1 Critical thinking skills

The core critical thinking skills include interpretation, analysis, evaluation, inference, explanation and self regulation as shown below:

Interpretation is to comprehend and express the meaning or significance of a wide variety of experiences, situations, data, events, judgements, conventions, beliefs, rules, procedures or criteria. It includes the sub skills of categorization, decoding significance and classifying meaning.

Analysis is to identify the intended and actual inferential relationships among statements, questions, concepts, descriptions or other forms of representations intended to express beliefs, judgments, experiences, reasons, information or opinions. Examining ideas, detecting arguments and analyzing arguments are sub skills of analysis.

Evaluation means to assess the credibility of statements or other representation which are accounts or descriptions of a person’s perception,
experience, situation, judgements, beliefs or opinion; and to assess the logical strength of the actual or intended inferential relationships among statements, descriptions, questions or other forms of representation. The experts also propose that evaluation is judging if an argument’s conclusion follows either with certainty or with a high level of confidence from its premises, judging the logical strength of arguments based on hypothetical situations, judging if a given argument is relevant or applicable or has implications for the situations at hand.

Inference means to identify and secure elements needed to draw reasonable conclusions to form conjectures and hypotheses; to consider relevant information and to reduce the consequences flowing from data, statements, principles, evidences, judgments, beliefs, opinions, concepts, descriptions, questions, or other forms of representation. The sub skills of inference are querying evidence, conjecturing alternatives and drawing conclusions.

Explanation means the ability to present in a cogent and coherent way the results of one’s reasoning. This means to be able to give someone a full look at the big picture, both to state and to justify that reasoning in terms of the evidential, conceptual, and contextual considerations upon which one’s results were based, and to present one’s reasoning in the form of cogent arguments. The sub skills under explanation are describing methods and results, justifying procedures, proposing and defending with good reasons one’s causal and conceptual explanations of events or points of view and presenting full and well reasoned arguments in the context of seeking the
best understanding possible.

Self regulation means self consciously to monitor one’s cognitive activities, the elements used in those activities and the results produced particularly by applying skills in analysis and evaluation to one’s own inferential judgements with a view toward questioning, confirming, validating or correcting either, one’s reasoning or one’s results. The two sub skills here are self examination and self correction.

According to Raymond S. Nickerson (1985), the characteristics of a critical thinker are:

i. using evidence skillfully and impartially, organising thoughts and articulating them concisely and coherently and distinguishing between logically valid and invalid inferences.

ii. suspending judgments in the absence of sufficient evidence to support a decision.

iii. understanding the difference between reasoning and rationalizing.

iv. attempting to anticipate the probable consequences of alternative actions.

v. understanding the idea or degrees of belief.

vi. seeing similarities and analogies that are superficially apparent.

vii. learning independently and having an abiding interest in doing so.

viii. applying problem solving techniques in domains other than there in which learned.
ix. clarity in stating the questions or concern.

x. orderliness in working with complexity.

xi. diligence in seeking relevant information.

xii. reasonableness in selecting and applying criteria.

xiii. care in focusing attention on the concern at hand.

xiv. persistence though difficulties are encountered.

xv. precision to the degree permitted by the subject and the circumstances.

xvi. stripping a verbal argument of irrelevancies and phrase it in its essential terms.

xvii. recognising the fallibility of one’s own opinions, the probability of bias in those opinions and the danger of weighting evidence according to personal preferences.

According to the National Council of Excellence in Critical Thinking Instruction (2006), “A well cultivated critical thinker- raises vital questions and problems formulating them clearly and precisely, thinks open mindedly within alternative systems of thought, recognizing and assessing as need be, their assumptions, implications and practical consequences and gathers and assesses relevant information, using abstract ideas, to interpret information effectively, comes to well reasoned conclusions and solutions, testing them against relevant criteria and standards”.

1.8 PROBLEM SOLVING ABILITY

Problem solving Ability is the highest form of learning in Gagne’s
theory of learning. Asubel (1998) views, “The ability to solve a problem is the primary goal of education”. Mathematics teaching and learning focuses to develop the ability to solve a wide variety of complex mathematical problems. To many mathematically literate people Mathematics is synonymous with solving problems, doing word problems, creating patterns, interpreting figures, developing geometric constructions, proving theorems etc. The National Council of Teachers of Mathematics (NCTM 2000) recommended that problem solving be the central focus of Mathematics teaching because it encompasses skills and functions, which are important parts of one’s everyday life.

Problem solving involves taking series of actions in the process of an investigation that seeks to bridge the gap between a problem state and the anticipated goal. A problem solving strategy, therefore, comprises action and steps taken by the learner to reach anticipated goal when faced with the problem situation. Problem solving behaviour occurs in novel or difficult situations in which a solution is not obtainable by the habitual methods of applying concepts and principles derived from past experience in very familiar situations.

Yewande (2000) was of the opinion that problem solving is using information and reasoning to overcome obstacle or barrier. Problem solving is a process of overcoming difficulties that appear to interfere with the attainment of a goal. It is a procedure of making adjustment in spite of
interferences.

Carpenter (1989) says that Problem solving activities are often viewed as a method to practice, applying new knowledge and skills learned earlier in a different context. Problem solving involves the ability to explore, think through an issue, and reason logically to solve routine as well as non routine problems.

Some of the specific characteristics of a problem solving approach are given below:

i. Interactions between students- students; and teacher- students.

ii. Teachers providing just enough information to establish background / intent to the problem and students clarifying, interpreting and attempting to construct one or more solution process.

iii. Teachers accepting right / wrong answers in a non evaluative way and guiding, coaching, asking insightful questions and sharing in the process of solving problems.

iv. Teachers knowing when it is appropriate to intervene, and when to step back and let the pupils make their own way.

v. A further characteristic is that a problem solving approach can be used to encourage students to make generalizations about rules and concepts, a process which is central to Mathematics.

According to Serrano, et. al. (2003), the problem solving is a complex mental process involving visualization, imagination, manipulation,
abstraction and the association of ideas. Problem solving requires unique and original responses. To speak of problem solving is to speak of thinking skills, these being the highest and most complex skills of human beings. Problem solving involves not only higher mental process, but also simpler processes such as memory, attention, representation, comprehension etc. In thought, one engages in mental activities such as the articulation of symbols and concepts, which lead us to the creation of new forms that culminate in problem solving.

Problem solving is based on the posing of open, suggestive situations that require from students an active attitude, an effort to find their own answers, and their own knowledge. Problem solving itself is a process where external elements (problems to be solved) are interrelated with one’s already existing knowledge in the subject (memory, simple rules, etc) and so called the cognosceitive strategies in order to obtain the adequate solution to the problem.

“Problem solving is a higher mental process where attitudes, prior knowledge and heuristic or algorithmic rules intervene in order to provide the best of possible answers to a problem where one did not exist” says Serran (1997). According to George Polya (1974), “To have a problem means to search consciously for some action appropriate to attain some clearly conceived but not immediately attainable aim. To solve a problem means to find such an action”. Schoenfeld, (1985) views, “Problem solving refers to
the process wherein students encounter a problem, a question for which they have no immediately apparent resolution or an algorithm that they can directly apply to get an answer”.

**1.8.1 Steps in solving Problems**

Problem solving was thus seen as means of developing student’s reasoning skills. The higher order reasoning skills, inferential strategies and divergent thinking patterns that are the essential factors to problem solving.

Developing methods for teaching problem solving skills effectively has been a concern of many educational writers and practitioners. Numerous authors, (Polya, 1974; Bransford, 1993; Campbell 1995) have developed generalized constructs for solving problems.

Polya (1974) suggested four steps to solve a problem:

i. Understand the problem.

ii. Devise a plan.

iii. Carry out the plan.

iv. Look back.

A modification of these steps was offered by Bransford in 1993. He suggested five steps known as IDEAL

i. Identify the problem.

ii. Define the problem through thinking about it and determining what information is relevant and what information is not.

iii. Explore solutions by looking at alternatives, brain storming and examining the problem from different points of view.
iv. Act on the strategies.

v. Look back and evaluate the effects of your activity.

Campel (1995) suggested step – by – step approach to solve problems. He calls this approach P.A.C.E.

i. P – Problem (identifying the goal).

ii. A – Alternative (determining possible solutions).

iii. C – Consequences (eliminating the likely consequences of one’s actions).

iv. E – Evaluation (selecting the most promising choice).

Marzano (1997) suggested the following steps in the process of problem solving:

i. Identify the goal to be accomplished.

ii. Identify the constraints or limiting conditions.

iii. Determine exactly how these constraints prevent the goal.

iv. Identify different ways of overcoming the constraints.

v. Select and try out the alternative that appears to be the best.

vi. Evaluate the effectiveness of the alternative you have tried.

Steps suggested by Mangal, S.K.(2008) are given below:

i. Problem Awareness.

ii. Problem Understanding.

iii. Collection of Relevant information.


v. Selection of Possible Solutions.
vi. Verification of the Concluded Solution.

1.9 NEED AND SIGNIFICANCE OF THE STUDY

Every individual has the ability to learn. Every individual is different but they can all learn. Not all individuals learn in the same way and it should, therefore, be taught in different ways. Universally, Mathematics is taught as one of the subjects in Schools, Colleges and Universities. Mathematics is considered as the queen of all Sciences. It is an essential subject taught to the students to develop the skills of reasoning, logical thinking and problem solving. Majority of the pupils feel that Mathematics is a difficult subject and it can be understood and followed only by intelligent students. Those who fail in the subject develop hatred towards it. At present majority of the Mathematics teachers follow traditional methods of instruction and learners tend to be passive listeners. No lesson can be effectively learned unless there is active pupil participation in it. In order to teach a heterogeneous group, teachers need to use a variety of different instructional strategies. In the words of Eggen and Kauchak (2001), “It is impossible to reach every student in the classroom by using only one instructional strategy. Students learn Mathematics by connecting new ideas to ideas that they already know. Teachers of Mathematics need to be able to understand what students know and how they can present new material, with their prior knowledge of Mathematics.” Hence, there is an imperative need to adopt learner centered approaches in the classroom.

Co-operative learning is based on the belief that students learn more when they are actively involved in the learning process. Active involvement
results in more understanding and ability to think than in passive learning. It challenges students to develop the ability to think critically, analyze problems and use appropriate learning resources. It is an act of believing in and practicing face-to-face interactive learning so as to encourage creativity and foster critical thinking through group processing.

Kessler (1992) observes that co-operative learning raises the level of learners’ curiosity and their spirit of questioning, infesting in them a democratic and scientific way of investigation of facts and findings and facilitating them to integrate critical thinking. The main goal of education and core objective of teaching learning process is to develop the learner as a critical thinking person.

Critical thinking is a process in which a person uses his mind to analyze or study information. Critical thinking is an important and necessary skill, because it can help the students to deal with mental and spiritual questions, and it can be used to evaluate people, policies and institutions and thereby avoiding social problems. Critical thinking processes are involved in essential elements of school curriculum and student’s development.

Human beings face multiple dimensional problems in their lives and they try to solve these problems in a particular way in the light of their previously gained knowledge and experience. In this regard it is essential for the students to be prepared for future or near future challenges by facing real life, or real life like problems in their learning environment and finding appropriate solutions of these problems. In the era of unprecedented breakthroughs in technology and constant change in many aspects of life,
educators are challenged more than ever before with the need to develop students who will be adaptable in fast changing environments. This calls for equipping students with better thinking skills and learning abilities. Problem solving is an essential but complex activity in Mathematics. One of the aims of teaching Mathematics through problem solving helps students to construct a deep understanding of mathematical ideas and process by engaging them in doing Mathematics, creating, conjecturing, exploring, testing and verifying.

Dave Atlas (2000) remarked that combining critical thinking and problem solving to the area of co-operative learning will not only enhance process acquisition, but increase relevancy and the affective domain to prepare students for an increasingly interdependent and connected world. The process of critical thinking from a problem – oriented vantage is both a way to better organise and interrelate existing knowledge as well as acquire more information. When students are to learn the working technique of critical thinking, they must be afforded the opportunities of problem solving. For this, class room environment must be conducive. In student centered and engaging class room, the emphasis shifts from end product to process. In this process oriented environment, learning elements involve not merely the acquisition of information, but also the development of skills for evaluating and interpreting facts.

As we know, this society is a social entity, with a premium on group behaviour and interaction. Students need mental flexibility, critical thinking skills and problem solving ability to survive in a rapidly changing world. This involves engaging students in discovering how to analyse, synthesize,
make judgments, and create new knowledge and to apply those skills to real-world situations. Thus, combining the process of the elements of critical thinking and problem solving ability with co-operative learning is a powerful and effective combination with significant learning outcomes for students in schools. Teacher’s behavior and method of teaching take both direct and indirect effects on critical thinking and problem solving abilities of students. Higher secondary period is the crucial one for the adolescents. Critical thinking and Problem solving abilities play a significant role in preparing the adolescent to set realistic goals and think of solutions needed to reach these goals. Hence, the responsibility of the teacher especially at the higher Secondary level becomes increasingly important to develop their ability to think critically and solve problems independently for better adjustment in a future complex society.

In Co-operative learning peer relations become more active, peer tutoring and peer reviews are done with delight and the students learn the subject matter thoroughly through teaching the other students. Co-operative learning endeavours one more effective, since they emphasis learning and acquiring skills through the process of a fully learner centered techniques and strategies. Co-operative learning groups are the most beneficial ones, since they encourage activities related to social and affective aspects. Co-operative learning fosters thinking skills, creativity and critical judgements. In the above context, the investigator being a teacher educator wanted to investigate whether cooperative learning is effective in developing critical thinking ability and problem solving ability in Mathematics of higher secondary