CHAPTER 1
INTRODUCTION

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INTRODUCTION

Education is the most effective tool ever known in the hands of mankind to develop children as responsible members of the society. The school serves as an established agent of education. It facilitates appropriate learning contexts resulting in knowledge, skills and attitudes in children which are the ingredients of a sound personality. It is in the classroom that learners analyse and evaluate their experiences, learn to doubt, to question, to investigate and to think independently. Each school subject has its own role in developing an integrated personality in a child. Mathematics education plays a vital role in imbibing the power of abstraction in the students.

Mathematics laid the foundation for the explosion of scientific knowledge, which brought about tremendous industrial and technological revolution that resulted in altered mode of living, thinking and culture. Today, Mathematics is not considered a mere subject of study. It has become a language for communication and thought process, through which man comprehends nature. Mathematical structure is not a self-sustained element with any hinges or connection but is a full cohesive set of concurrent links, each of its stability being relative to the other and the whole.

Mathematics is a core subject in our education system both at the primary and secondary levels. In 1960s Mathematics education in almost all countries developed qualitatively by including the teaching of modern Mathematics in school education. It is considered as a difficult subject by most of the pupils mainly due to its abstract nature. The National Curriculum Framework (NCF, 2005) has rightly identified ‘a sense of fear and failure regarding Mathematics learning among majority of children’. The fear regarding the subject is a major problem in the teaching and learning of Mathematics.

1.1 Mathematics Education in the Indian Context

The vision with which Mathematics has been placed in the school curriculum has evolved over the years. The system of Nai Talim (New Education) that emerged in India, oriented towards building responsible, capable and educated Indians,
emphasised the importance of Mathematics education. It viewed Mathematics in terms of its use for the day-to-day requirements of the people. The emphasis was on ensuring the calculations necessary for the survival of the child in the circumstances in which he/she grows.

In the 1950s and the 1960s, India developed Mathematics education as a step towards industrialisation and scientific research. The Education Commission (1964-66) report underlined the need for Mathematics and Science in school as well as higher education and it emphasised the importance of learning Mathematics for the development of Science and technology. The National Policy of Education (1986) states, “Mathematics should be visualised 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 concomitant to any subject involving analysis and reasoning”.

In 1990s and 2000s Minimum Learning Levels (MLL) were introduced which formed the basis of the curriculum and textbooks. National Curriculum Framework (NCF, 2000) emphasised the implementation of MLL. The MLL was initiated to provide equitable education to all children across the country. It includes the learning of language, Mathematics and environmental studies in the primary classes by breaking the content into small chunks/competencies that all children are expected to achieve. Assessment and evaluation were based on competencies in the form of measurable and observable behaviour, demonstrated by the child as a result of educational inputs.

The NCF (2005) has given directions to school and teacher education all over India regarding Mathematics education. It emphasises ‘mathematisation’ of the child’s thought process as the main goal of Mathematics education. It enlarges the vision of school Mathematics taking it beyond the areas of obvious utility in daily life, by enriching students’ scope of thought and visualisation, and in turn enabling them to relate to the world and Mathematics. It recognises Mathematics as an important part of the development of the human mind, as an addition to the human ability to absorb, visualise, logically understand, build arguments, prove statements and in a sense interact with and deal with the world. It states, “the aim of school Mathematics is to develop ‘useful’ capabilities, particularly those relating to numeracy – numbers, number operations, measurement, decimals and percentages. It also aims at developing the child’s resources to think and reason
mathematically, to pursue assumptions to their logical conclusion and to handle abstraction” (NCF, 2005).

Based on the recommendations of the NCF (2005), the curriculum revision programme of Kerala was conceptualised. Kerala Curriculum Framework (KCF, 2007) suggests, “the learning of Science and Mathematics at the upper primary level has to be more activity based and relevant in real life situations. The ‘fear factor’ among learners about Mathematics has to be overcome by directing their interest to nature and to real life situations, encouraging them to discover the mathematical logic behind the object they see. This could be accomplished by mathematising their thought process.” Though the recommendations and suggestions of NCF (2005) and KCF (2007) have implemented in schools, the status of Mathematics education have not yet improved. As the learning of this particular subject demands cognitive training, proper methods and models which facilitate such training should be sought. Cognitive Apprenticeship Model is one such model which facilitates training in the successful completion of complex cognitive tools. The investigator intended to experiment the potential of Cognitive Apprenticeship Model on reviving Mathematics education.

1.2 Theoretical Overview of the Study

Theories are statements that explain particular phenomenon by specifying certain relationships among variables. It scientifically summarises knowledge within a given field. A theory explains the relationship between variables. On the basis of such relationships researchers make deductions and predictions about what will happen under specific conditions. A clear understanding of the existing theory in the area of investigation is necessary for making the investigation clearer, specific and goal oriented. This section includes the theoretical framework of the Cognitive Apprenticeship Model, Metacognitive Outcomes and Social Skills.

1.2.1 Theoretical Framework of the Cognitive Apprenticeship Model

Various learning theories have focused on how learning takes place. The behaviourists’ understanding of learning has been in use for a long period. This was followed by the theory of information processing which has become an extended behaviourism. The concept of learning has changed from information processing to
the construction of knowledge. This construction process never starts at zero, but always has its basis in an already existing knowledge structure. This existing knowledge or experience is the starting point for any interpretation of information which leads to the construction of knowledge. This learning process is not determined by general laws but depends very much on the situation and the context in which it takes place. Thus one’s own learning process becomes an accelerating and structural element in learning.

The curriculum in Indian schools has been revised focusing on the constructivist approach. The philosophy of constructivism proposes that children construct their own understanding and knowledge of the world through experiencing things and reflecting on these experiences, testing ideas and approaches based on their prior knowledge and experience, applying them to new situations and integrating new knowledge gained with pre-existing intellectual constructs. The teacher is a facilitator or a coach, who guides the students’ critical thinking, analysing and synthesising abilities throughout the learning process. The teacher is also a co-learner in the process.

The concept of Cognitive Apprenticeship originates from the Social Constructivist theory based on the work of Vygotsky, and is mostly related to the Situated Cognition theory of Brown, Collins, and Duguid, (1989). Situated cognition is a theory of instruction that suggests that learning is naturally tied to authentic activity, context and culture. Cognitive Apprenticeship provides practical steps for applying situated cognition theory. This model is also supported by Bandura’s (1997) theory of modelling which postulates that for modelling to be successful, the learner must be attentive, must have access to and retain the information presented, must be motivated to learn and must be able to reproduce the desired skill. The detailed description about the theoretical aspects of the Cognitive Apprenticeship Model is presented below.

1.2.1.1 The Child as Apprentice: Vygotsky (1896-1934)

Lev Semenovich Vygotsky (1896-1934) believed that human activities take place in cultural settings. One of his key ideas was that our specific mental structures and processes can be traced to our interactions with others. These social interactions are more than simple influences on cognitive development; they actually create our
cognitive structures and thinking processes. Vygotsky conceptualised development as the transformation of socially shared activities into internalised processes. Two major themes in Vygotsky’s views explain how the social process forms learning and thinking. They are (i) the social source of individual thinking and (ii) the role of tools in learning and development, especially the tool of language.

i) The Social Source of Individual Thinking

Vygotsky assumed that every function in a child’s cultural development appears twice: first, on the social level and later on the individual level. Higher mental processes appear first between people as they are constructed during shared activities. The processes are in turn internalised by the child and thereby become part of the child’s cognitive development. So, for Vygotsky, social interaction is the origin of higher mental processes such as problem solving.

At birth, we are social beings capable of interacting with others, but able to do little by or for ourselves. But gradually we move towards self sufficiency and independence. By participating in social activities our abilities are transformed. According to Vygotsky, cognitive development involves an active internalisation of problem solving processes that take place as a result of mutual interaction between children and those with whom they have regular social contact. This is the reverse of how Piaget saw things. Piaget’s idea of ‘the child as a scientist’ is replaced by Vygotsky’s idea of ‘the child as an apprentice’. The child acquires the culture’s knowledge and skills and the resultant development through graded collaboration with parents and teachers who already possess them.

ii) Cultural Tools and Cognitive Development

Vygotsky emphasised the importance of the tools that culture provides to support thinking. He believed that all higher-order mental processes, such as reasoning and problem solving are mediated by psychological tools, such as language, signs and symbols. Adults teach these tools to children during day-to-day activities and the children internalise them. As children engage in activities with adults or more capable peers, they exchange ideas and ways of thinking about or representing concepts. These co-created ideas are internalised by children.
Language is critical for cognitive development. Vygotsky proposed, “the specifically human capacity for language enables children to provide for auxiliary tools in the solution of difficult tasks, to overcome impulsive action, to plan a solution to a problem prior to its execution and to master their own behaviour” (Vygotsky, 1978). Vygotsky believed that language in the form of private speech guides cognitive development. Young children use language not only for social communication but also to plan, guide and monitor their behaviour in a self-regulatory fashion. Language and thought initially develop independently of each other and then merge. All mental functions have external or social origins. Children must use language to communicate with others before they can focus inward on their own thoughts. Children also must communicate externally and use language for talking to oneself for a long period of time before the transition period occurs. After a while, the self-talk becomes second nature to children and they can act without verbalising. When this occurs, children have internalised their egocentric speech in the form of inner speech, which become their thoughts. Vygotsky believed that children who use a lot of private speech are more socially competent than those who don’t. He argued that private speech represents an early transition in becoming more socially communicative (Shamier & Tzuriel, 2004).

Vygotsky’s theory has stimulated considerable interest in the view that knowledge is situated and collaborative. That is, knowledge is distributed among people and environments, which include objects, artifacts, tools, books and the communities in which people live. This suggests that knowing can best be advanced through interaction with others in cooperative activities. Within these basic claims, Vygotsky articulated unique and influential ideas about the relation between learning and development. These ideas especially reflect his view that cognitive functioning has social origins. One of Vygotsky’s unique ideas was his concept of the Zone of Proximal Development (ZPD).

**Zone of Proximal Development**

Zone of Proximal Development (ZPD) is Vygotsky’s term for the range of tasks that are too difficult for children to master alone but that can be learned with guidance and assistance of adults or more skilled children. Thus, the lower limit of the ZPD is the level of problem solving reached by the child working independently. The
upper limit is the level of additional responsibility the child can accept with the assistance of an able instructor. That is, it refers to a level of development attained when children engage in social interaction. In Vygotsky’s view, peer interaction, scaffolding and modelling are important ways to facilitate individual’s cognitive growth and knowledge acquisition. In order to promote our students’ cognitive development, we should present some classroom task, and design assignment which can perform successfully only with assistance. Students with different ZPDs need different tasks and assignments. When adults and other skilled individuals assist children in performing difficult tasks, they often use a technique called ‘scaffolding’ to support children in their effort.

**Scaffolding:** It is a technique of extending and changing the level of support to the children in accomplishing a cognitive task. Over the course of a teaching session, a more skilled person either teacher or an advanced peer adjusts the amount of guidance to fit the student’s current performance level. That is, scaffolding refers to the kind of guidance and support adults provide to children by whom children acquire their knowledge and skill. Teachers should provide sufficient support to enable their students to perform challenging tasks successfully. When students develop increasing competence, the teacher can gradually withdraw those support mechanism, eventually allowing students to perform the task independently. When the teacher removes such scaffolding, he allows and encourages students to stand on their own feet.

Scaffolding in the classroom sometimes takes the form of a Cognitive Apprenticeship. Cognitive Apprenticeship involves two people jointly constructing a means for tackling a problem. In Cognitive Apprenticeship, teachers often act as a model to the students. Then teachers or skilled peers support the student’s efforts at doing the task. Finally, they encourage students to continue their work independently. The term Apprenticeship underscores the importance of activity in learning and highlights the situated nature of learning.

**1.2.1.2 Situated Cognition**

Situated Cognition is an important assumption in the social constructivist approaches. It refers to the idea that thinking is situated in social and physical contexts, not within an individual’s mind. It conveys the idea that knowledge is embedded in and connected to the context in which it is developed. This theory
suggests that learning is naturally tied to authentic activity, context and culture (Brown, Collins, & Dugid, 1989).

Collins (1988) defined situated learning as the notion of learning knowledge and skills in contexts that reflect the way they will be used in real life. The real world is not like studying in school. Situated learning is more like an apprenticeship where novices, with the support of an expert guide, take on more and more responsibility until they are able to function independently. Knowledge is seen not as individual cognitive structures but as a creation of the community over a period of time. The practices of the community constitute the knowledge of that community. Through learning the individual becomes more able to participate in those practices.

The Cognitive Apprenticeship Model is directly related to situated cognition theory and provides practical steps for applying it. In situated cognition approaches, students collaborate with one another and their instructor toward some shared understanding. Instructors who advocate such approaches believe that there is a ‘culture’ of learning which can be cultivated. Students can process concepts and information more thoroughly when multiple opinions, perspectives, or beliefs must be accounted for across a group.

1.2.1.3 Bandura’s Social Cognitive Theory

The Cognitive Apprenticeship Model is also related to the social cognitive theory which states that social and cognition factors, as well as behaviour, play important role in learning. Cognitive factors involve the students’ expectations for success; social factors include students’ observing their parent’s achievement behaviour. Bandura (1997) is one of the main architects of the social cognitive theory. He says that when students learn, they can cognitively represent or transform their experiences.

Bandura’s social cognitive theory distinguishes between enactive and vicarious learning. Enactive learning is learning by doing and experiencing the consequences of one’s actions. Consequences are seen as providing information. Interpretations of the consequences create expectations, influence motivation and shape beliefs. Vicarious learning is learning by observing others. While observing, children focus their attention, construct images, remember, analyse and make
decisions that affect learning. Cognitive Apprenticeships are examples of vicarious learning that is learning by observing others.

**Learning by Observing Others**

Through observational learning we learn how to perform a behaviour and learn the consequences of performance of that behaviour in specific situations. Bandura (1986) noted that observational learning includes four elements: paying attention, retaining information or impressions, producing behaviours and being motivated to repeat the behaviours.

**Attention:** Paying attention is a requisite for learning through observation. In teaching, teacher has to ensure students’ attention to the critical features of the lesson by making presentations clear and highlighting important points.

**Retention:** In order to imitate the behaviour of a model, we have to remember it. This involves mentally representing the model’s actions as verbal steps or visual images, or both. Retention can be improved by mental rehearsal or by actual practice. Practice helps us remember the elements of the desired behaviour.

**Production:** For the smooth performance of the behaviour of the model, a great deal of practice, feedback and coaching about subtle points are needed. In the production phase, practice makes the behaviour smoother.

**Motivation and Reinforcement:** For the performance of behaviour, motivation is needed. Reinforcement can play several roles in observational learning. The anticipation of reinforcement for imitating the behaviour of the model, motivate the learner to pay attention, remember and reproduce the behaviours. In addition reinforcement is important in maintaining learning.

Thus Bandura (1989) emphasised that learning occurs observationally through modelling. Modelling is a process in which the child learns by keenly observing the behaviour, attitudes and emotional reactions of others, most commonly of the people nearest to them like parents, members of the family, teachers and the older members of the society. From observing others the child forms an idea of how new behaviours are performed, and this coded information serves as a guide for imitated action. A cognitive modelling strategy, with teachers and competent students serving as cognitive models, is a key characteristic of Cognitive Apprenticeship. Modelling in
Cognitive Apprenticeship helps the teacher to show how a process unfolds and give reasons.

### 1.2.1.4 Cognitive Apprenticeship Model

Collins, Brown, and Newman (1989) proposed Cognitive Apprenticeship to teach students the thinking and problem-solving skills involved in school subjects. They called this updated concept of apprenticeship ‘Cognitive Apprenticeship’ to emphasise two issues. First, the term ‘apprenticeship’ emphasised that Cognitive Apprenticeship is aimed primarily at teaching processes that experts use to handle complex tasks. Like traditional apprenticeship, Cognitive Apprenticeship emphasises that knowledge must be used in solving real-world problems. Conceptual knowledge and factual knowledge are learned by being used in a variety of contexts, encouraging a deeper understanding of the concepts and facts and a rich web of memorable associations between them and the problem solving contexts. This dual focus on expert processes and learning in context are shared by both traditional apprenticeship and Cognitive Apprenticeship.

Second, ‘cognitive’ emphasised that the focus is on cognition and metacognition, rather than physical skills and processes. Traditional apprenticeship evolved to teach domains in which the process of carrying out target skills is externally visible, and readily available to both the student and the teacher for observation, comment, refinement and correction. The methods used in classroom do not give the provision for the teacher to refine the students’ ability to apply the knowledge and skills during problem solving since these methods are incapable of revealing the cognitive processes going on in students’ minds. At the same time, students do not usually have access to the cognitive problem solving processes of instructors as a basis for learning through observation. In order to apply the Cognitive Apprenticeship methods to learn cognitive skills, a change in the learning environment is needed to make these internal thought processes externally visible. Cognitive Apprenticeship is designed to bring these cognitive processes into open, where students can observe, enact and practice them.

Lave (1988) identified some of the crucial features of traditional apprenticeship. First and foremost, apprenticeship focuses closely on the specific methods for carrying out tasks in a domain. Secondly, skills are instrumental to the
accomplishment of meaningful real world tasks, and learning is embedded in a social and functional context, unlike schooling, where skills and knowledge are usually abstracted from their use in their world. An apprentice learns domain-specific methods through a combination of what Lave called observation, coaching and practice. In this sequence of activities, the apprentice repeatedly observes the master and his or her assistants executing (or modelling) the target process, which usually involves a number of different, but interrelated sub-skills. The apprentice then attempts to execute the process with guidance and help from the master (i.e. coaching). A key aspect of coaching is guided participation: the close support which the master provides to help the novice complete an entire task, even before the novice has acquired every skill required. As the learner masters the increasing numbers of component skills, the master reduces his or her participation, providing fewer hints and less feedback to the learner. Eventually, the master fades away completely, when the apprentice has learned to smoothly execute the whole task.

Framework for Cognitive Apprenticeship learning Environment

Cognitive apprenticeship focuses on four dimensions that constitute any learning environment: content, method, sequencing and sociology.

i) Content

Recent cognitive research has begun to differentiate the types of knowledge required for expertise. In particular, researchers have begun to distinguish between the concepts, facts and procedures associated with expertise and various types of strategic knowledge. The term strategic knowledge refers to the usually tacit knowledge that underlies an expert’s ability to make use of concepts, facts and procedures as necessary to solve problems and accomplish tasks. This sort of expert problem solving involves problem heuristics and the strategies that control the problem-solving process. Another type of strategic knowledge, often overlooked, includes the learning strategies that experts use to acquire new concepts, facts and procedures in their own or another field.

**Domain Knowledge** includes the concepts, facts and procedures explicitly identified with a particular subject matter that is generally explicated in school textbooks, class lectures and demonstrations.
Heuristic strategies are generally effective techniques and approaches for accomplishing tasks that might be regarded as ‘tricks of the trade’; they don't always work, but when they do, they are quite helpful. Most heuristics are tacitly acquired by experts through the practice of solving problems. In Mathematics, a heuristic for solving problems is to try to find a solution for simple cases and see if the solution generalises.

Control strategies, or metacognitive strategies control the process of carrying out a task. Control strategies have monitoring, diagnostic, and remedial components. Decisions on how to proceed in a task generally depend on an assessment of one's current state relative to one's goals, on an analysis of current difficulties and on the strategies available for dealing with difficulties.

Learning strategies are strategies for learning how to learn new concepts, facts and procedures.

ii) Method

Teaching methods that emphasise apprenticeship give students the opportunity to observe, engage in and invent or discover expert strategies in context. The six teaching methods associated with Cognitive Apprenticeship fall roughly into three groups. The first three methods, modelling, coaching and scaffolding, are the core of traditional apprenticeship. They are designed to help students to acquire an integrated set of skills through processes of observation and guided practice. The next two methods, articulation and reflection, are methods designed to help students to focus their observations of expert problem solving and to gain conscious access to and control of their own problem solving strategies. The final method, exploration is aimed at encouraging learner autonomy, not only in carrying out expert problem solving processes but also in defining or formulating the problems to be solved.

Modelling involves an expert performing a task so that the students can observe and build a conceptual model of the processes that are required to accomplish it. In cognitive domains, this requires the externalisation of usually internal processes and activities.

Coaching consists of observing students while they carry out a task and offering hints, challenges, scaffolding, feedback, modelling, reminders and new tasks
aimed at bringing their performance closer to expert performance. Coaching is related to specific events or problems that arise as the student attempts to accomplish the task. Here the teacher coaches students while they ask questions, clarify their difficulties, generate summaries and make predictions.

**Scaffolding** refers to the supports the teacher provides to help the student carry out the task. Coaching refers broadly to all the different ways that coaches foster learning, whereas scaffolding refers more narrowly to the supports provided to the learner. These supports can take either the form of suggestions or help or they can take the form of physical supports. Fading involves the gradual removal of supports until students can independently perform their task.

**Articulation** includes any method of getting students to explicitly state their knowledge, reasoning, or problem solving processes in a domain. Inquiry teaching (Collins & Stevens, 1983) is a strategy of questioning students to lead them to articulate and refine their understanding. Also, teachers can encourage students to articulate their thoughts as they carry out their problem solving, or have students assume the critic or monitor role in cooperative activities in order to articulate their ideas to other students.

**Reflection** involves enabling students to compare their own problem solving processes with those of an expert, another student and ultimately, an internal cognitive model of expertise. Reflection is enhanced by the use of various techniques for reproducing or ‘replaying’ the performances of both the expert and the novice for comparison. Some form of ‘abstracted replay’, in which the critical features of the expert and the student performances are highlighted, is desirable (Collins & Brown, 1988).

**Exploration** involves guiding students to a mode of solving problems on their own. Enabling them to do exploration is critical, if they are to learn how to frame questions or problems that are interesting and that they can solve. Exploration as a method of teaching involves setting general goals for students and then encouraging them to focus on certain sub goals of interest to them, or even to revise the general goals as they come upon something more interesting to pursue.
iii) Sequencing

Cognitive Apprenticeship provides some principles to guide the sequencing of learning activities.

**Increasing complexity** refers to the construction of a sequence of tasks such that, more and more of the skills and concepts necessary for expert performance are required (Burton, Brown, & Fischer, 1984; White, 1984).

**Increasing diversity** refers to the construction of a sequence of tasks in which a wider variety of strategies or skills are required. As a skill becomes well learned, it becomes increasingly important that tasks requiring a diversity of skills and strategies be introduced so that the student learns to distinguish the conditions under which they are capable of applying. Moreover, as students learn to apply skills to more diverse problems, their strategies acquire a richer net of contextual associations and thus are more readily available for use with unfamiliar or novel problems.

**Global before local Skills** is the sequencing principle which allow students to build a conceptual map before attending to the details of the terrain (Norman, 1973). Having a clear conceptual model of the overall activity helps learners make sense of the portion that they are carrying out, thus improving their ability to monitor their own progress and to develop attendant self-correction skills.

iv) Sociology

The apprentices learn their skill not in a special, segregated learning environment, but in a co-operative manner. They are surrounded both by masters and other apprentices, all engaged in the target skills at varying levels of expertise. And they are expected, from the beginning, to engage in activities that contribute directly to the production of knowledge, advancing quickly toward independent skilled production. As a result, apprentices learn skills in the context of their application to real-world problems within a culture, focused on and defined by expert practice. Furthermore, certain aspects of the social organisation of apprenticeship encourage productive beliefs about the nature of learning and of expertise that are significant to learners' motivation, confidence, and most importantly, their orientation toward problems that they encounter as they learn. These considerations suggest several characteristics affecting the sociology of learning.
Situated learning is a critical element in fostering learning is allowing students to carry out tasks and solve problems in an environment that reflects the nature of such tasks in the world (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991). Dewey created a situated learning environment in his experimental school by enabling the students design and build a clubhouse (Cuban, 1984), a task that emphasises arithmetic and planning skills.

Community of practice refers to the creation of a learning environment in which the participants actively communicate and engage in the skills involved in expertise (Lave & Wenger, 1991; Wenger, 1998). Such a community leads to a sense of ownership, characterised by personal investment and mutual dependency. It cannot be forced, but it can be fostered by common projects and shared experiences.

Intrinsic motivation is related to the issue of situated learning and the creation of a community of practice there is the need to promote intrinsic motivation for learning. Lepper and Greene (1979) discussed the importance of creating learning environments in which students perform tasks because the tasks are intrinsically related to a goal of interest to them, rather than for some extrinsic reason, like getting a good grade or pleasing the teacher.

Exploiting cooperation refers to having students work together in a way that fosters cooperative problem solving. Learning through cooperative problem solving is both a powerful motivator and a powerful mechanism for extending learning resources.

While looking at the characteristics of each of the four dimensions included in the framework for designing learning environment, the content and sequencing dimensions focus on isolated mastery of discrete lower level skills. But both methods and sociological dimensions advocate a high level of teacher-student interaction. In the Cognitive Apprenticeship environment, learning is embedded in a setting that is more like work, where the tasks have some ‘authentic’ relationships to students’ lives and where there is a community of people working together to accomplish real-world goals. Table 1.1 shows the framework of Cognitive Apprenticeship Model (Collins, Hawkins, & Carver, 1991) for designing the learning environment.
### Table 1.1

**Principles of Designing Cognitive Apprenticeship Environment**

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Types of knowledge required for expertise</th>
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<tbody>
<tr>
<td>Content</td>
<td><strong>Domain Knowledge</strong> Subject matter-specific concepts, facts and procedures</td>
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<tr>
<td></td>
<td><strong>Heuristic strategies</strong> Generally applicable techniques for accomplishing tasks</td>
</tr>
<tr>
<td></td>
<td><strong>Control strategies</strong> General approaches for directing one’s solution process</td>
</tr>
<tr>
<td></td>
<td><strong>Learning strategies</strong> Knowledge about how to learn new concepts, facts, and procedures</td>
</tr>
<tr>
<td>Method</td>
<td><strong>Modelling</strong> Teacher performs a task so that students can observe</td>
</tr>
<tr>
<td></td>
<td><strong>Coaching</strong> Teacher observes and facilitates students when they perform a task</td>
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<td></td>
<td><strong>Scaffolding</strong> Teacher provides supports to help the students perform a task</td>
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<td></td>
<td><strong>Articulation</strong> Teacher encourages students to verbalise their knowledge and thinking</td>
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<td></td>
<td><strong>Reflection</strong> Teacher enables students to compare their performance with others</td>
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<td></td>
<td><strong>Exploration</strong> Teacher invites students to pose and solve their own problems</td>
</tr>
<tr>
<td>Sequencing</td>
<td><strong>Increasing complexity</strong> Meaningful tasks in the order of gradual increase in difficulty</td>
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<td></td>
<td><strong>Increasing diversity</strong> Practice in a variety of situations to emphasise broad application</td>
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<td></td>
<td><strong>Global to local skills</strong> Focus on conceptualising the whole task before executing the parts</td>
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<tr>
<td>Sociology</td>
<td><strong>Situated learning</strong> Students learn in the context of working on realistic tasks</td>
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<td></td>
<td><strong>Community of practice</strong> Communication about different ways to accomplish meaningful tasks</td>
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<td></td>
<td><strong>Intrinsic motivation</strong> Students set personal goals to seek skill and solutions</td>
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<tr>
<td></td>
<td><strong>Cooperation</strong> Students work together to accomplish their goals</td>
</tr>
</tbody>
</table>
1.2.2 Theoretical Framework of Metacognition

Metacognition is defined as ‘thinking about thinking’. ‘Meta’ is a Greek word meaning after, behind or beyond. The term Metacognition was introduced by Flavell in 1976 to refer to ‘the individual’s own awareness and consideration of his or her cognitive processes and strategies’ (Flavell, 1979). It refers to that unique human capacity of people to be self-reflective, not just to think and know but to think about their own thinking and knowing. Also it refers to higher order thinking, which involves active control over the cognitive process engaged in learning. Cognition is the mental processing of information, which is the function of the human mind that allows perceptions to grow into conceptions. When we have control over our own cognitive functions it is termed as Metacognition. The processes of thinking are emphasised in the concept of Metacognition. That means, Metacognition is the cognitive ability to monitor and self-regulate one’s thinking. It is the monitoring and regulating of one’s own thinking processes. It is a conscious verification of one’s personal cognitive status that allows a person to develop and expand upon new knowledge. The main distinction between cognition and Metacognition is that Metacognition is considered to be ‘second-order cognitions’. Generally cognition is a ‘constant flow of information’ and Metacognition is knowledge and awareness of processes and the monitoring and control of such knowledge and processes.

Metacognition has been referred to as knowledge about knowledge or executive processes that occur after cognition. However, most often the concept of Metacognition is explained as Metacognitive knowledge and cognition about cognitive phenomena. This definition includes knowledge of generic cognitive strategies, along with monitoring, evaluating and reflecting them, and beliefs about factors that affect cognitive strategies. This definition is extremely broad. In most cases, Metacognition refers more narrowly to monitoring cognitive processes and influences on them while one focuses on a specific task.

1.2.2.1 The Categorisation of the Taxonomy of Metacognition

Flavell (1976) offered an early, commonly accepted, definition of Metacognition as knowledge concerning one’s own cognitive processes and products or anything related to them. More than a decade later, Paris and Winograd (1990) identified that most theorists emphasise two aspects of Metacognition, knowledge of
cognition (Metacognitive Knowledge) and control over cognition (Metacognitive regulation or regulation of cognition). Metacognitive knowledge refers to acquired knowledge about cognitive processes and Metacognitive Regulation refers to knowledge that can be used to control cognitive processes.

i) Knowledge of Cognition or Metacognitive Knowledge

Knowledge of cognition or Metacognitive knowledge is defined as the knowledge individuals have about their own cognition and cognition in general (Pintrich, 2002; Schraw & Moshman, 1995). This includes knowledge of learning strengths and weaknesses and knowledge about strategies and their appropriate application, especially in complex problems. It is the knowledge about when, how and why to engage in various cognitive activities and include person, task and strategy knowledge. It also involves self awareness relying upon self-knowledge and self-appraisal through reflectivity. Knowledge of cognition involves and is influenced by personal theories or beliefs about capabilities and abilities. These influences include self-system components such as self-esteem, attributional beliefs, self-appraisal or self-reflection and self-efficacy. Self-appraisal involves the reflective, static assessment of one's knowledge, ability, task and context or strategy applicability. Jacobs and Paris (1987) further delineated the knowledge component of Metacognition into declarative, procedural and conditional aspects of knowledge. Declarative, procedural and conditional knowledge involve knowledge and processes related to person, task and strategy variables and are essential Metacognitive processes.

a) Declarative Metacognitive Knowledge

Declarative knowledge is stable, familiar, constant and established long-term knowledge which involves self-knowledge, self-awareness and a sensitivity to and evaluation of this knowledge. It also includes knowledge of oneself and others as cognitive beings, of tasks and task demands and of strategies. Kluwe (1982) describes two forms of declarative knowledge: ‘domain knowledge’ and ‘cognitive knowledge’. He describes domain knowledge as ‘an individual’s stored information about the domains of reality’. Cognitive knowledge refers to ‘an individual’s stored assumptions, hypotheses and beliefs about thinking’.
b) Procedural Metacognitive Knowledge

Procedural knowledge refers to knowledge of processes and actions or essentially knowing how (Schraw & Moshman, 1995). It is also labeled as metastrategic knowing-knowledge and awareness of the processes or how to meet task demands or task objectives. It involves metastrategic understanding of the application of strategies or procedures which facilitate the realisation of cognitive goals (Jacobs & Paris, 1987; Kulwe, 1982). It also refers to knowledge of how to execute procedures such as learning strategies. It is knowledge that is demonstrated when we perform a task.

c) Conditional Metacognitive Knowledge

Conditional knowledge involves ‘knowing when and why to use declarative and procedural knowledge’. It is discussed mainly in terms of declarative and procedural strategy knowledge, application and effectiveness in various task situations (Jacobs & Paris, 1987; Schraw & Moshman, 1995). It specifically refers to knowledge and awareness of the conditions which affect learning such as ‘why’ strategies are effective, when they should be applied and ‘when’ they are appropriate.

ii) Regulation of Cognition

Regulation of Cognition is also known as Metacognitive Skills or Metacognitive Regulation. It is the secondary process of Metacognition and is also labeled as executive control or functioning. It involves Metacognitive processes that facilitate and support the evaluation and control of the learning process and is especially important to facilitate problem solving. These processes include predicting, planning, cognitive monitoring, diagnosing, regulating, checking and evaluating learning processes, difficulties and outcomes in problem solving situations (Borkowski et al., 2000; Brown, 1987; Hacker, 1998; Schraw & Moshman, 1995). Regulation of Cognition is also referred to as ‘self-management’ of cognition involving reflective ‘self-appraisal’ and it supports the awareness of Metacognitive experiences, especially during problem solving. Marzano (2001) identified that goal specification, process monitoring, monitoring clarity and monitoring accuracy as elements of regulatory processes.
Jacobs and Paris (1987) demarcated Metacognitive control into the process of planning, evaluation and regulation. Planning includes the selection of a strategy to achieve a goal. Evaluation is monitoring of the progress made toward achieving the goal. Regulation refers to the revision or modification of the strategies to achieve the goal. Hacker (1998) described executive control as consisting of both monitoring and regulating. Monitoring includes identifying the task, checking the progress of task completion and predicting the eventual outcome. Regulation includes allocation of resources specifying the number of steps to complete a task and the intensity and speed with which it will be completed. Paris and Lindauer (1982) described Metacognitive control during reading and writing as consisting of planning, monitoring and evaluation. In this case, planning refers to the selection of strategies and the allocation of resources, for monitoring comprehension, evaluation and examination of progress towards goals that can lead back to more planning and more monitoring. What is common to all of these articulations of the control process is some initial analysis of what to do, making a plan to do something, evaluating the usefulness of that plan and then making appropriate revisions or modifications to the original plan.

1.2.2.2 How does Metacognition Develop?

Thinking about thinking develops in children through their growing awareness of different viewpoints and the experience of self conflict when their understanding is challenged. Children vary in their ability to solve problems and to learn from experience. These individual differences are related to differences of intelligence, difference in experience including the experience of being taught and to differences in the use of Metacognitive processes.

Teachers can use a variety of strategies to enhance Metacognition, independent of grade level and subject area. Modelling by teacher is one of the instructional strategies with the probability of greatest influence on students. Since students learn best by imitating the adults around them, the teacher who publicly demonstrates Metacognition will probably produce students who use Metacognition. Some indicators of teachers’ visible Metacognitive behaviour are sharing their planning, describing their goals and objectives and giving reasons for their actions. It also includes seeking feedback and evaluation of their actions from others and having a
clearly stated value system and making decisions consistent with that system. Teachers have to demonstrate understanding and empathy by listening to and accurately describing the ideas and feelings of others.

1.2.3 Theoretical Frame Work of Social Skills

Social Skills are the skills that enable a person to interact and communicate with others in a meaningful way. Good Social Skills are critical to success in life. These skills enable us to know what to say, how to make good choices and how to behave in diverse situations. Recent research (Usha & Nagalakshmi, 2008) suggests that a child’s long-term social and emotional adaptations, academic and cognitive development and citizenship are enhanced by frequent opportunities to strengthen social competence during childhood. Social Skills are necessary to build relationships with others. The process by which members of a society learn these skills is called socialisation. According to Page and Garwood (1983), children learn to control and direct their own behaviour to accomplish goals. Although the content of Social Skills varies across cultures, the processes by which these skills acquired, are universal.

1.2.3.1 Definitions

There are different definitions of Social Skills available in the literature. Social Skills have been defined as the ‘ability to express feelings or to communicate interests and desires to others’ (Liberman, King, & DeRisi, 1975). Some authors define it as ‘the ability to express both positive and negative feelings in the interpersonal context without suffering consequent loss of social reinforcement’ (Hersen & Bellack, 1977). It has also been defined as ‘the ability of an interactant to choose optimal communicative behaviours for successful accomplishment of his own interpersonal goal during the interaction while maintaining the face and line of his fellow interactants (Wiemann, 1977). According to Cartledge and Milburn (1980) Social Skills are defined as those social, interpersonal and task related behaviours that produce positive consequences in the classroom settings. Social Skills are acceptable learned behaviours that enable individuals to interact in ways that elicit positive responses and assist in avoiding negative responses from them (Cartledge and Milburn, 1995).
Social Skills are components of behaviour that help an individual understand and adapt across a variety of social settings. Walker (1983) defined Social Skills as ‘a set of competencies that a) allow an individual to initiate and maintain positive social relationships, b) contribute to peer acceptance and to a satisfactory school adjustment, and c) allow an individual to cope effectively with the larger social environment’. Social Skills can also be defined within the context of social and emotional learning recognising and managing our emotions, developing care and concern for others, establishing positive relationships, making responsible decisions and handling challenging situations constructively and ethically (Zins, Weissbert, Wang, & Walberg, 2004). With this understanding, researchers and educators seek to build and evaluate students’ Social Skills within variety of social contexts.

1.2.3.2 Components of Social Skills

Argyle (1995) described the components of Social Skills as follows:

Assertiveness: It is the ability to influence or control other. It has sometimes been equated with social competence. It is contrasted both with aggression and passive behaviour. Lazarus (1973) proposed that assertiveness has four main components: refusing requests, asking for favours and making requests, expressing positive and negative feelings and initiating, continuing and ending general conversation.

Empathy: It is the capacity to share the perceived emotion of another and to understand the point of view of others, to ‘take the role of the other’.

Co-operation: It is taking account of the goals of others, as well as one’s own, and coordinating behaviour so that both shall be reached. All social activities take more than one to do them. Many instances of Social Skills failure can be seen as a failure of co-operation. It is the tendency to join others in their efforts in order to reach a mutually desirable goal. Co-operation is working purposefully and optimistically for achieving one’s goals. It helps us to be self-reliant and prompts the interest of others to the extent of sacrificing one’s own time, energy and money.

Concern for others: It is central to all close relationships. It means formation of a strong emotional bond with others like possession of confidence, respect for family and friends, participation in personal decisions, feeling of security in relationship with
authorities and congenial associations with peer group. It also refers to politeness combined with kindness shown in the behaviour towards others.

**Interpersonal relationships:** Interpersonal relationship skills means being able to make and keep friendly relationships, which can be of great importance to one’s mental and social well being. It also means maintaining good relationships with family members and the significant others which is an important source of social support.

**Verbal communication:** This lies at the heart of nearly all human social performance and Social Skills. Most skilled moves or signals are basically verbal, and furthermore have to fit into a conversational sequence. Conversation is closely coordinated with, and supported by, non-verbal signals.

**Non-verbal communication:** Assertiveness and interpersonal relationships require special non-verbal styles of voice, face and posture. Nonverbal expression consists of facial expression, gaze, proximity, gestures and nonverbal voice.

**Self-presentation:** This is a special goal of Social Skill, which is important not only for the self-esteem of interactors, but also to enable others to know how to react. Self-image is the whole set of thoughts that individuals have about themselves, including roles, personality traits and body image. Self-esteem is the extent to which individuals think well of themselves.

### 1.2.3.3 Role of Social Interaction in Learning

The classroom is the environment in which children must learn to navigate. Successful learning requires students to interact closely with teachers and peers. Social Skills have a big impact on a child’s ability to succeed in an academic setting. The classroom becomes both a training ground for development of Social Skills and an arena in which those skills are put to use.

Christopher, Nangle, and Hansen (1993) suggested that social interactions are useful for a child’s adjustment in a number of ways:

- Establishing support systems for emotional and social needs
- Developing moral judgement and social values
- Improving or maintaining self esteem
Promoting interpersonal and adult behaviour
Recreation including entertainment
Enhancing status within the group

Among the different constructivist psychologists, the idea given by Vygotsky is directly related to the role of social interaction in learning process. He argued that it is as a result of the social interaction between the growing child and other members of the society that the child acquires the tools of thinking and learning. He was of the opinion that society and culture provide children with opportunities to develop. In this view social interaction is considered to be the source from which all higher functions, such as thinking, logical reasoning, attention and language arise. These types of social engagement of children, teachers and adults in shared activities contribute to the rapid growth of children whereby they become skilled participants in the intellectual and social lives of their society. Social interaction and social engagements are essential aspects of child development.

Social constructivism emphasises the importance of culture and context in understanding what occurs in society and constructing knowledge based on this understanding. This perspective is closely associated with many contemporary theories, most notably the developmental theories of Vygotsky, Bruner and Bandura. Vygotsky focuses on the connections between people and the socio cultural context in which they act and interact in shared experiences.

In order to translate the philosophy of constructivism into actual practice, many instructional designers are working to develop more constructivist environments and instructional prescriptions. One of the most important of these prescriptions is the provision of instruction in relevant contexts. Brown, Collins, and Dugid (1989) suggest that knowledge and the conditions of its use are inextricably linked. Learning occurs most effectively in contexts, and that context becomes an important part of the knowledge base associated with learning.

1.3 Need and Significance of the Study

The aim of teaching Mathematics is to understand and make sense of Mathematics by the learners. The learners must be actively involved in the learning tasks to process information and understand concepts. Since Mathematics is a subject
of significance by itself and also concomitant to other subject areas, it is included as a compulsory subject in the school curriculum. Experience has shown that the majority of students normally fail in Mathematics at the end of class X (NCERT, 2000). In order to provide teaching and learning experience for all learners in the Mathematics classroom, teachers have to revamp their teaching strategy.

Kajapeer (2001) explained the causes for low Mathematics achievement of students as, students (a) are not taught the appropriate strategies, (b) cannot regulate the study strategies and (c) do not understand how to apply these strategies. Cardelle-Elawar (1992) observed that low achieving students are often found to be confused when they are confronted with a mathematical problem and are unable to explain the strategies they need to employ to find the correct solution. When Sharma (2005) evaluated the methods of teaching Mathematics used by different teachers, he could see that teachers, using new methods like visual aids and other laboratory equipment to make students understand better, were very few. Behera (2009) revealed that those who can verbalise the process of arriving at a solution are better at problem solving.

Survey of contemporary educational outcomes in terms of cognitive and affective domain achievement reveal that high level cognitive skills need not result in good behaviour and Social Skills. Development of these skills is highly dependent on what teachers do in the classrooms. Teachers generally consider themselves to be repositories of knowledge and think that their role is to supply their students with information. To face the challenges of life, students need, not only knowledge but also skills such as Metacognitive and Social Skills.

For developing Metacognitive Skills, students must be able to monitor and regulate their own cognitive processes. Researchers (Kumar, 2010; Ozsoy & Ataman, 2009) suggested that teachers should directly teach Metacognitive strategies to students. One way of teaching for Metacognition is to explicitly infuse the language of thinking and learning into the framework of teaching and classroom discussion. Teachers should explicitly bring out the knowledge and cognitive strategies involved in a problem situation while attempting its solution through several means: telling the student what needs to be done, stepping the student through the problem, modelling appropriate strategies and explaining while modelling. Modelling of thinking processes involved in expert problem solving is especially important for enhancing
Metacognition. The expert helps the student by reducing his/her cognitive workload. Teachers provide a scaffold that enables a student to solve a problem that is beyond his or her unassisted efforts. The teacher does those parts of the task that the student cannot, while allowing the student to participate as fully as possible. Thus a true dialogue between the teacher and the student will develop. Also teachers take less of the workload as students demonstrate increasing competence. This ceding of control encourages the student to complete more of the task on his or her own.

Social Skills are patterns of social behaviour which make individuals socially competent. Desirable Social Skills are essential for successful functioning in life such as handling interpersonal relations, taking appropriate decisions, communicating effectively, coping with stress and analysing social issues in order to find solutions. The extent to which children and adolescents possess good Social Skills can influence their academic performances, behaviour, social and family relationships and involvement in co-curricular activities. Social Skills are linked to the quality of the school environment and school safety. Lack of these skills can lead to maladjustment, such as delinquency, dropping out of school, low academic achievement, antisocial behaviour and adult psychosis.

Social Skills are a pre-requisite for a positive climate in classroom setting. Developing Social Skills are of utmost importance in the educational process. Many of our students lack the requisite skills to cope up with the social life. In order to develop Social Skills, the student should get the opportunity for interaction with other members in the society. It highlights the need for developing appropriate strategies and methods for the inculcation of Social Skills among the students. The studies conducted on Social Skills focused on the general cooperative learning method on Social Skills (Court, 1995; Dollman et al., 2007; Fetissoff, Kry, & Skilling, 2008). Archer-kath, Johnson, and Johnson’s (1994) study revealed that in order to improve students’ achievement, different Social Skills training techniques can be adopted.

Cognitive Apprenticeship Model reveals its effectiveness with respect to varied skills, abilities and behavioural changes. It combines the effective characteristics of several instruction-psychological models, such as reciprocal teaching (Brown & Palincsar, 1989), procedural faciliation (Bereiter & Scardamalia, 1989) and modelling (Schoenfeld, 1985). Shyu’s (1997) study revealed that Cognitive
Cognitive Apprenticeship Model aimed at the development of higher order thinking skills which are pre-requisites for solving mathematical problems.

The main issue addressed by the investigator in the present study was how to develop Metacognitive Outcomes and Social Skills by using the cognitive tool. The investigator felt that Cognitive Apprenticeship is a model which serves the demands for developing Metacognition as well as Social Skills. Cognitive Apprenticeship provides a methodology for acquiring cognitive and Social Skills through six phases of teaching: Modelling, Coaching, Scaffolding, Articulation, Reflection and Exploration. Cognitive Apprenticeship can be used in classrooms as an instructional design or learning technique in which students learn with the help and guidance of a teacher or expert. This guided participation helps the student to achieve a task that would be too hard or complicated if attempted independently.

Although several researchers attribute immense potential to the Cognitive Apprenticeship Model, there is little empirical evidence concerning its implementation and effectiveness in a regular classroom setting. The investigator could not find any experimental study which explores the effectiveness of Cognitive Apprenticeship Model on Metacognition and Social Skills especially among secondary school students in India. However, available studies could provide good guidance to develop instructional material based on Cognitive Apprenticeship Model and test its effectiveness on Achievement in Mathematics, Metacognitive Outcomes and Social Skills. Building on current research, there was ample scope to explore the effectiveness of the Cognitive Apprenticeship Model to make the teaching learning process more meaningful and interesting through enhancing Achievement in Mathematics, Metacognitive Outcomes and Social Skills. This has led the investigator to select the present problem for research.

1.4 Statement of the Problem

The present study is entitled, “Effectiveness of Cognitive Apprenticeship Model on Achievement in Mathematics, Metacognitive Outcomes and Social Skills”.

1.5 Operational Definitions of the Key Terms

1.5.1 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 potential of a teaching method or model to produce desired result in the Achievement in Mathematics, Metacognitive Outcomes and Social Skills of secondary school students.

1.5.2 Cognitive Apprenticeship Model

Cognitive Apprenticeship Model was developed by Brown, Collins, and Dugid (1989) based on the situated cognition theory. This Model suggests that cognitive skills can be acquired in authentic contexts and by communicating with peers and experts. It is a model designed to improve students’ thinking and problem-solving skills through the learning of school subjects. It involves six steps, namely, Modelling, Coaching, Scaffolding, Articulation, Reflection and Exploration.

1.5.3 Achievement in Mathematics

Achievement in Mathematics refers to the behavioural evidence of cognitive outcomes in the discipline of Mathematics which is measured by scores obtained on the Achievement Test in Mathematics constructed by the investigator.

1.5.4 Metacognitive Outcomes

Metacognition refers to the higher order thinking which involves active control over the cognitive processes. Paris and Winograd (1990) emphasised two aspects of Metacognition as Knowledge of Cognition and Regulation of Cognition. In the present study, Metacognitive Outcomes refer to behavioural evidence in the context of mathematical problem solving which reveals Knowledge of Cognition and Regulation of Cognition. The components of Knowledge of Cognition were Declarative Knowledge, Procedural Knowledge and Conditional Knowledge and the components of Regulation of Cognition selected were Prediction, Planning, Monitoring and Evaluation.
1.5.5 Social Skills

Social Skills are defined as those social, interpersonal and task-related behaviours that produce positive consequences in the school classroom settings (Cartledge & Melburn, 1980). In the present study, Social Skills refer to social, interpersonal and task related behaviours that produce positive consequences in the classroom settings. It is measured in terms of Cooperation, Interpersonal Relationship, Communicative Ability and Concern for Others.

1.6 Variables of the Study

In the study, the investigator had selected the variables namely independent, dependent and extraneous variables.

1.6.1 Independent Variables

The independent variables are the conditions or characteristics that the experimenter manipulates or controls in his or her attempt to ascertain their relationship to the observed phenomena (Best & Khan, 2008). In the study, the independent variable was the treatment variable which had two levels – the experimental treatment using the Cognitive Apprenticeship Model and the routine treatment using the Existing activity oriented method.

1.6.2 Dependent Variables

The dependent variables are the conditions or characteristics that appear, disappear or change as the experimenter introduces, removes or changes the independent variables (Best & Khan, 2008). The three dependent variables selected for the study were:

1. Achievement in Mathematics
2. Metacognitive Outcomes
   a) Knowledge of Cognition
   b) Regulation of Cognition

   a. Knowledge of Cognition includes the following components:
      i) Declarative Knowledge
      ii) Procedural Knowledge
      iii) Conditional Knowledge
b. Regulation of Cognition includes the following components:
   i) Prediction
   ii) Planning
   iii) Monitoring
   iv) Evaluation

3. Social Skills
   The selected components of Social Skills were:
   a. Cooperation
   b. Interpersonal Relationship
   c. Communicative Ability
   d. Concern for Others

1.6.3 Extraneous variable
   The extraneous variable selected for the study was Intelligence, since Intelligence may affect Achievement, Metacognitive Outcomes and Social Skills irrespective of other learning conditions.

1.7 Objectives of the Study
   1. To prepare instructional materials based on the Cognitive Apprenticeship Model for teaching Mathematics to the students of standard eight
   2. To prepare and validate the tools, namely, a) Achievement Test in Mathematics to measure Achievement b) Scale of Metacognitive Outcomes to measure the Metacognitive Outcomes in mathematical problem solving and c) Social Skills Rating Scale to measure the Social Skills of the students of standard eight
   3. To analyse the scores on (a) Intelligence (b) Achievement in Mathematics (c) Metacognitive Outcomes and (d) Social Skills of the students in the experimental and control groups
   4. To find out the relationship among Intelligence and the pretest scores on the dependent variables, namely, Achievement in Mathematics, Metacognitive Outcomes and Social Skills of the students of standard eight
5. To find out whether there is any significant difference between the pretest scores of the students in the experimental and control groups on (a) Intelligence (b) Achievement in Mathematics (c) Metacognitive Outcomes and (d) Social Skills

6. To find out whether there is any significant difference between the pretest and posttest scores of the students in the experimental group on (a) Achievement in Mathematics (b) Metacognitive Outcomes and (c) Social Skills

7. To find out whether there is any significant difference between the pretest and posttest scores of the students in the control group on (a) Achievement in Mathematics (b) Metacognitive Outcomes and (c) Social Skills

8. To find out whether there is any significant difference between the posttest scores of the students in the experimental and control groups on (a) Achievement in Mathematics (b) Metacognitive Outcomes and (c) Social Skills

9. To find out whether there is any significant difference between the gain scores of the students in the experimental and control groups on (a) Achievement in Mathematics (b) Metacognitive Outcomes and (c) Social Skills

10. To find out the effectiveness of the Cognitive Apprenticeship Model over the existing method on Achievement in Mathematics, Metacognitive Outcomes and Social Skills, by controlling the influence of Intelligence and pretest scores on the dependent variables

11. To find out whether there is any significant difference between the gain scores of boys and girls in the experimental group on (a) Achievement in Mathematics (b) Metacognitive Outcomes and (c) Social Skills

1.8 Hypotheses of the Study

1. There is significant relationship among Intelligence and the pretest scores on the dependent variables, namely, Achievement in Mathematics, Metacognitive Outcomes and Social Skills of the students of standard eight.

2. There is no significant difference between the pretest scores of the students in the experimental and control groups on (a) Intelligence (b) Achievement in Mathematics (c) Metacognitive Outcomes and (d) Social Skills.
3. There is significant difference between the pretest and posttest scores of the students in the experimental group on (a) Achievement in Mathematics (b) Metacognitive Outcomes and (c) Social Skills.

4. There is significant difference between the pretest and posttest scores of the students in the control group on (a) Achievement in Mathematics (b) Metacognitive Outcomes and (c) Social Skills.

5. There is significant difference between the posttest scores of the students in the experimental and control groups on (a) Achievement in Mathematics (b) Metacognitive Outcomes and (c) Social Skills.

6. There is significant difference between the gain scores of the students in the experimental and control groups on (a) Achievement in Mathematics (b) Metacognitive Outcomes and (c) Social Skills.

7. There is significant effect of the Cognitive Apprenticeship Model over the Existing method on Achievement in Mathematics, Metacognitive Outcomes and Social Skills, by controlling the influence of Intelligence and pretest scores on the dependent variables.

8. There is significant difference between the gain scores of boys and girls in the experimental group on (a) Achievement in Mathematics (b) Metacognitive Outcomes and (c) Social Skills.

1.9 Methodology in Brief

Methodology is the science of proper methods and sequenced procedures. It reflects the phases adopted in any field of activity. In this session, the investigator gives a brief idea about the procedure adopted in the accomplishment of the study.

1.9.1 Method adopted

The method selected for the present study was experimental and the design selected was pretest-posttest nonequivalent-groups design, where there were one experimental group and one control group. The experimental group was taught through Cognitive Apprenticeship Model and the control group through the Existing method practiced in the schools which follow the curriculum designed by the Board of Secondary Education in Kerala State.
1.9.2 Sample for 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 in Kerala State. Keeping in view of the experimental nature of the study and its demands and limitations, the investigator selected St. Mary’s Higher Secondary School, Kidangoor of Kottayam district, Kerala State for the experimentation. Two intact classes from the four divisions of standard eight in the school were selected randomly. Of the two classes selected, one was randomly assigned as the experimental group and the other as control group, each consisting of 38 students. Thus a group of 76 students from two classes was taken as the sample.

1.9.3 Tools and Techniques Used

The effectiveness of the Cognitive Apprenticeship Model over the Existing method was assessed with the help of pretests and posttests on Achievement in Mathematics, Metacognitive Outcomes and Social Skills. The tools used for the study were:

1. Achievement Test in Mathematics (ATM) constructed by the investigator to test Achievement in Mathematics of the students of standard eight

2. Scale of Metacognitive Outcomes (SMO) constructed by the investigator to measure the Metacognitive Outcomes in mathematical problem solving of the students

3. Social Skills Rating Scale (SSRS) constructed by the investigator to measure the Social Skills of the students

4. Raven’s Standard Progressive Matrices (RPM, 1996) to measure Intelligence

1.9.4 Procedure for Data collection

In order to find out the effectiveness of the Cognitive Apprenticeship Model over the Existing method, the investigator adopted the following procedure. Before conducting the experiment, Raven’s Progressive Matrices test in Intelligence was administered to obtain the scores on Intelligence which is an extraneous variable for the present study. The investigator administered Achievement Test in Mathematics (ATM) to measure the Achievement in Mathematics, the Scale of Metacognitive
Outcomes (SMO) to measure the Metacognitive Outcomes in mathematical problem solving and the Social Skills Rating Scale (SSRS) to measure the Social Skills of the students in the experimental and control groups before and after the experiment. The experimental group was taught through the Cognitive Apprenticeship Model and the control group through the Existing activity oriented method practiced in the schools which follow the curriculum designed by the Board of Secondary Education in Kerala State. The two groups were given equal attention during the course of the experiment.

1.9.5 Statistical Techniques Used

The collected data were analysed using the statistical techniques such as Mean, Median, Mode, Standard Deviation, Skewness, Pearson’s product moment coefficient of correlation, test of significance of correlation, test of significance of difference between the means of two independent groups, test of significance of difference between means of two correlated groups, Analysis of Co-variance (ANCOVA) and Multivariate Analysis of Co-variance (MANCOVA).

1.10 Delimitations of the Study

1. The study was confined to the students of standard eight from Kottayam District of Kerala State.

2. Only selected components of the Metacognitive Outcomes and Social Skills were included in the study.

3. Study was conducted in the school which follows the curriculum designed by the Board of Secondary Education in Kerala State.

4. The content selected for preparation of the instructional material was delimited to only certain portions prescribed in the Mathematics textbook of standard eight.

1.11 Organisation of the Report

The study has been reported in five chapters. The details are given below:

Chapter- 1 ‘Introduction’ contains a detailed description of the theoretical framework of the study, need and significance of the study, statement of the problem, objectives of the study, hypotheses set for the study, methodology in brief, delimitations of the study and details of the organisation.
Chapter- 2 ‘Review of Related Literature’ presents the review of related literature on the Cognitive Apprenticeship Model, Metacognitive Outcomes, Social Skills and Achievement in Mathematics. An earnest attempt is made to review all available studies in the concerned area.

Chapter- 3 ‘Methodology’ gives a description of the design of the study, variables selected, preparation of the instructional materials, the description of the tools employed for the collection of the data, selection of the sample and statistical techniques used for the analysis of data collected.

Chapter- 4 ‘Analysis and Interpretation of the Data’ is concerned with the analysis of the data collected for the study followed by the findings and discussion of the results.

Chapter- 5 ‘Summary and Conclusions’ summarises the study in retrospect. The major conclusions and findings emerged from the results of the analysis, educational implications and suggestions for further research are also included.

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