DEVELOPING THINKING SKILLS OF EARLY SCHOOL CHILDREN THROUGH SCIENCE ACTIVITIES

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Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Education at the Institute of Education and Research University of the Punjab Lahore September 2009
Accepted by the faculty of the Institute of Education and Research, University of
the Punjab, Lahore, in partial fulfilment of the requirements for the degree of
Doctor of Philosophy in Education.

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ABSTRACT

The experimental study investigated the effect of science activities (‘Let’s Think!’) on the development of thinking skills of early school children in Pakistan. A total of 101 experimental and 130 control group children of grade 1 participated in the study. The sample comprised 4 experimental and 5 control groups was selected from 6 different schools. The mean age of children was 83 months (SD=11.4) at the time of pretest. Thirty science activities were conducted as intervention for a period of 1 year. The Schemata i.e., Seriation, Classification, Time Sequence, Spatial Perception, Causation, Theory of Mind and Concrete Modeling were addressed in the activities. For measuring the cognitive development of children, drawing and conservation tests were used as pre and posttest. The purpose of drawing test, that intended to measure the schema of spatial perception, was to see the effect of science activities on the schema addressed in the intervention program. The conservation test was used to examine the effect of science activities on the schema other than those addressed in the intervention program. Independent sample t-test was applied to see the difference between the mean gain scores of the experimental and the control group. Hedges’ g effect size was calculated on the gain scores to measure the magnitude of effect on the thinking skills of children. The results of the study showed that the gain scores of the experimental group on the drawing and the conservation tests were significantly higher than those of the control group. The effect of intervention on the drawing and the conservation tests was significant both in boys and girls. However, the values of the effect sizes on both of the tests were higher in the girls than the boys. When age-wise comparison was made, it was observed that the effect of intervention on the drawing test was significant at age 6+, 7+ and 8+ years. In case of the conservation test, however, it was significant at the age 6+ and 7+ years. The value of the effect size on conservation test was the highest at the age 6+, which dropped gradually in the age 7+ and 8+ years. Furthermore, the effect of intervention on the drawing and the conservation tests was significant in the girls at age 6+ and 7+ years, whereas for the boys, it was significant at the age 6+ only. Phases of rapid brain growth
and plateau and the gender differences in these phases give an account of the differential effect of intervention on age and gender. The results of the study suggest that thinking skills intervention programs aiming at the development of general thinking ability of children should be introduced in schools at appropriate time.
ACKNOWLEDGEMENT

All praises and thanks be to Allah Almighty, the Lord of the Worlds, the Creator of the heavens and the earth. Glory, gratitude and admiration be to Allah, Who created the Man, bestowed him with intellectual potentials and abilities of highest order, taught him the eloquent speech, honored the Human Being and gave him marked preference over other creatures.

The researcher is highly grateful to the supervisor of the dissertation, Prof. Dr. Hafiz Muhammad Iqbal, Dean, Faculty of Education for his guidance, encouragement, and support for the study. The researcher was lucky enough for having a supervisor that was expert in the field. She is thankful to him for managing his time despite his busy schedules and for providing the valuable and critical suggestions for the improvement of the dissertation. His reflective feedback and cooperation was of enormous value for the successive phases of development of the dissertation.

The researcher is highly obliged to Philip Adey for his guidance and quick response on each query throughout the study. Special thanks for him for providing feedback on the scanned scored sheets of drawing tests. Thanks are due to Steve Higgins for providing scholarly guidance on statistical issues and for providing excel sheet for calculating Hedge’s g effect size. The researcher is thankful to the school administration and teachers who cooperated and participated in the study.

The researcher pays gratitude to her parents for the opportunity, support and cooperation they provided for conducting the study with full concentration. Very special thanks for those special persons who encouraged the researcher and extended their cooperation during the study. The researcher is grateful to all those teachers, colleagues, fellows, friends, relatives, and others who provided academic and/or moral support and facilitated the researcher in any way.

A. S.
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CHAPTER I

Introduction

In the present world scenario of extraordinary speed and ingenuity towards globalization, things are happening and changing so rapidly that nothing seems constant except change itself. The main concern of institutions is preparing for change and handling the unexpected without falling prey to stagnation and suffocation associated with an inability to churn the status quo. Social, business, political and educational institutions are being forced to anticipate the need of the future and that they must do before it is too late.

Preparing for the change, for the unexpected, and for the future requires skills, which can aptly called new life skills. Survival, it is said by those with a foresight into the future, will depend on the skills associated with thinking, for instance creativity, critical thinking, problem solving, and decision making. Human beings are inherently blessed with these life skills, though most often these skills remain latent, hidden, unexplored and underdeveloped. All over the world the educational institutions are considered powerful factor in developing thinking skills, though other social institutions such as the family also plays an important role. Educational institutions are changing the way they educate the future generation. The most important of these changes is the goal of teaching. The knowledge explosion has made knowledge or content a common commodity. The real challenge is the ability to learn how to learn and how to use what you learn aptly, intelligently, and creatively and this requires well polished and well sharpened thinking skills. Stakeholders of education are recognizing that thinking skills are the demand of the day and are more important in this era than they ever were. They are demanding that developing thinking skills should be an affirmed objective of education at all levels and in all fields so as to enable the students to think for themselves (Pithers & Soden, 2000).
The important question is when and how to work on developing, sharpening and polishing thinking skills. Sharpening and polishing can go on for the whole life time but developmental stages need attention, for there seems to be a time period in human life when maximum gain can be achieved through intervention. Early childhood is the most important period of one's life. The significance of early childhood has been recognized by specialists of a variety of disciplines including biology, neuroscience, economics, behavioral sciences and education. Early years of life are crucial because they provide strong foundation for the rest of life. Intervention during early childhood can change the life trajectory of a person (Young, 2002). This period is crucial for physical, psychosocial and cognitive development. All these types of developments are vital as well as interlinked with each other. Development of thinking is linked with cognitive development. However, development of brain provides the biological foundation for the development of thinking and social interaction and scaffolding contributes towards its enhanced development. Cognitive development includes changes in thinking, intelligence and language (Santrock, 2006) and it is this that distinguishes human beings from the other creatures. Human beings are unique among all the creatures because of their thinking and reasoning abilities, their use of language and their ability to learn which has resulted in an extensive heritage and repertoire of knowledge and skills that is continuously increasing for thousands of years. Children, especially in their early childhood period, have great potential to readily acquire and absorb this body of knowledge and skills, and in this process education plays a key role (Fischer, et al., 2007).

As to the question of how to develop the important life skill of thinking, one can refer to numerous studies conducted on this topic. But first it is useful to differentiate between two schools of thought on cognitive development. The intelligence tradition view takes intellectual capacity as fixed. Hence the possibility of significant gain on
attempts at intervention for improving thinking skills was considered unlikely. The more recent view takes thinking as a skill and not as an inherently fixed and unchangeable characteristic. Thinking skill tradition emerged in the second half of the twentieth century, which recognized that thinking skills can be developed like motor skills. Interventions for enhancing thinking skills, have been tried in various contexts, using different approaches and generally positive results have been reported (Wilson, 2000; Fisher, 2005).

Cognitive Acceleration is one of the most successful thinking skills intervention programs that is based on theoretical foundations of Piaget and Vygotsky (Adey & Shayer, 1994; Shayer, 1999). It considers the development of thinking as a part of overall development and puts added emphasis on development rather than learning (Adey & Shayer, 1994). Improving the quality of student learning is the major concern of theorist, researchers and practitioners. Theorists and educationists are striving to build theories and propose strategies to enhance the quality of learning. According to Adey and Shayer (1994), if general intellectual capacity of children is developed, it would result in better learning and improved performance of children in academic sphere.

The thinking process consist of three components namely the content, thinking skills and thinking dispositions (Orlich, Harder, Callahan, Trevisan, & Brown, 2007). Still another component of ‘a challenging task’ is required for developing intervention programs. Content is important because it not only acts as a vehicle for applying thinking skills but also determines the selection of the kinds of thinking skills. Thinking skills, on the other hand, are the fundamental cognitive functions with the help of which we perform large mental operations and a challenging and problematic situation acts as the context in which thinking can operate. Lastly, thinking dispositions are the affective components which stimulate the process of thinking (Costa, 2001).
Thinking skills can be developed through various subjects. However, intervention provided in the subject of science was found to be more effective, the reason of which according to Higgins, Hall, Baumfield, and Moseley (2005) is that the thinking skills are the major focus of the science itself. Science is an essential part of education during early school years and one of the main reasons of teaching science at this level is to develop thinking skills and critical attitude among the students (Byrne & Johnstone, 1987). The main focus of science at this stage is to introduce the children to the procedure and values of science in order to arouse curiosity and to develop scientific attitude and skills in children (Chisman, 1990). Developing and enhancing thinking skills during early age may provide a foundation for scientific thinking in later years. For the enhancement in a child’s cognitive development, appropriate stimulating and interactive learning environment is vital. In this regard, play and activities do a better job for children rather than focusing on scholarly studies (Ministry of Education, 2008).

In a developing country like Pakistan, the importance of thinking skills at early childhood is recognized at least in verbal discussions and official documents. It is recognized that children have high potential for cognitive development during early childhood period (Ministry of Education, 2008). Effects of what happens in early years may last for the whole life. Experiences during this stage shape the foundation of learning and a person’s ability to learn in future is determined by the experience he receives at this time (Ministry of Education, 2007). National Plan of Action on Education for All (Ministry of Education, 2003 b) identifies the need for improving all aspects of quality of education and recognizes the importance of essential life skills. The Plan highlights the importance of project oriented and activity based curricula especially at early childhood level, which encourages enquiry, creativity and thinking. But, unfortunately in most developing countries including Pakistan, due attention is not being given to the
development of the thinking skills of children at this age. According to Myers (2002), developing countries are spending less than 1% of their educational budget on early childhood programs. Traditional ways of teaching are still being used, due to which most students lack initiative, skill, independence and creativity which results in deficiency in intellectual development of the students (Pakistan Montessori Council, 2005).

Intervention programs have been tried in various content areas and at various levels. Higgins et al. (2005) conducted meta-analysis on thinking skill development programs conducted all over the world. They reported only one study on thinking skill development in Pakistan that was conducted by Iqbal (Iqbal & Shayer, 2000). However, this study was conducted at secondary level. No substantial research has been done in Pakistan for the development of thinking skills at early childhood level, which is a very sensitive and promising area of research. The importance of thinking skills, recognition of the need of its enhancement in the developmentally crucial early childhood period and still its neglect in Pakistan makes the background of the present study.

Statement of the Problem

The current experimental study investigates the effect of science activities based on Cognitive Acceleration on the development of thinking skills of early school children in Pakistan and explores the factors that contribute towards the development of thinking skills at this level. The study compares the effect of intervention on children of different ages and gender and explores the critical ages for boys and girls during which science activities are most effective in accelerating the development of thinking skills.

Objectives of the Study

The objectives of the study were the following.

1. To investigate the effect of science activities on the development of schema addressed in the intervention program (spatial perception).
2. To investigate the effect of science activities on the development of schema other than those addressed in the intervention program (conservation).

3. To compare the effect of science activities on the cognitive development of children of public and private early schools.

4. To compare the effect of science activities on the cognitive development of boys and girls of early school.

5. To identify the age group of early school children in which science activities are most effective for developing thinking skills.

**Research Questions**

The research questions of the study were the following:

1. To what extent science activities can accelerate the development of the schema addressed in intervention program (spatial perception)?

2. To what extent science activities can accelerate the development of the schema other than those addressed in the intervention program (conservation)?

3. Do the science activities affect the development of thinking skills of children of public and private sector schools in the same way?

4. Do the science activities affect the development of thinking skills of boys and girls in the same way?

5. In which age group of early school children science activities are most effective for the development of thinking skills?

**Significance of the Study**

The current study explores the effect of science activities based on cognitive acceleration approach on the development of thinking skills of early school children in Pakistan. The findings of the study provided research-based evidence to the teachers about the content and methodology of activities that can develop thinking skills of their
students. Activities designed to target the schema of concrete operational level while incorporating the principles of cognitive acceleration are significantly and highly effective for the development of thinking skills of early school children. The study throws light on the comparative effect of the intervention on the children of different gender and ages. It informs about the age at which intervention has the strongest effect on the development of general cognitive processing capability of children. The study also reveals the appropriate age groups of boys and girls in which intervention led to the significant effect on the development of their thinking skills. These results, when used by the teachers will lead to better learning and improved performance of children in the academic sphere as well as life in general.

Institutions responsible for teachers’ professional development during pre-service and in-service education can benefit from the results of the study. Teacher education institutions should revise and modify their existing scheme of studies and incorporate courses and content materials regarding the philosophies and methodologies of thinking skills programs including cognitive acceleration. They should focus on the enhancement of the competencies of prospective teachers to equip them with the techniques and strategy with the help of which they can accelerate cognitive development of early school children. In-service education for teachers regarding the philosophy and methodology of cognitive acceleration can also be arranged to enhance their capacity and to enable them to adapt and use such methodologies and classroom practices that lead towards the development of thinking skills of children at this level. Improving teaching practices at the early school and primary levels will lead to better learning of children and achieving the purpose of education.

Results of the study guide early school education curriculum planners, textbook writers and policy makers towards the development of activity-based curricula with the
principles of cognitive acceleration. Designing such curricula and creating opportunities for children at appropriate age would lead to better results in terms of developing their thinking skills, accelerating their cognitive development and in turn, producing a brighter generation for the nation.

**Delimitation**

The study was delimited to the children of grade 1. It was conducted in two public and four private schools of Lahore. Only those schools were selected where school administration was accommodative to allow conducting experimental research. Those schools were preferred which had at least two sections so that one section can be taken as experimental group and the other as control group.

**Operational Definitions**

Thinking skills. ‘Thinking skills’ are the fundamental cognitive functions or ‘building blocks’ with the help of which we perform larger mental operations or processes like concept formation, inductive and deductive reasoning, creative thinking, critical thinking, decision making and problem solving. Focusing, information gathering, remembering, organizing, analyzing, generating, integrating and evaluating are the categories of thinking skills. Piaget names ‘building block’ of thinking as schema (pl. schemata).

Early school children. In the current study, ‘early school children’ is used for the children of grade 1. Average age of these children was 83 months (SD=11.4) at the time of pretest.

Science activities. ‘Let’s Think’ activities were implemented for the development of thinking skills among children. These activities were based on the Piaget’s schema of concrete operational stage. Schemata addressed in the intervention program were: *seriation, classification, time sequence, spatial perception, causality and rules of game.*
**Gain scores.** Gain score is the difference between a child’s performance on a test and his or her performance on a previously administered test. In the current study, drawing and conservation tests were administered before and after the intervention and the gain scores were calculated by subtracting pretest scores from posttest scores.

**Effect size.** Effect size is the difference between the two means divided by standard deviation (Cohen, 1988). In other words, it is just the standardized mean difference between the two groups. It is a way of quantifying the size of the mean difference of the two groups (Coe, 2002, September). Commonly the pooled standard deviation $\sigma_{pooled}$ is used (Rosnow & Rosenthal, 1996) to calculate the effect size. The pooled standard deviation is the root mean square of the two squared standard deviations (Cohen, 1988). Effect size was calculated on the mean gain scores of experimental and control groups.

$$\text{Effect size} = \frac{M_e - M_c}{\sigma_{pooled}}$$

Hedges’ $g$ method was used to estimate the effect size. It is an inferential measure, which is usually computed by using the square root of the mean square error from the analysis of variance testing for differences between the two groups (Higgins et al., 2005).
CHAPTER II

Review of Related Literature

A large body of knowledge exists on the topic of thinking, including its origin, development, acceleration and factors associated with it. Much has been learned about how thinking operates and can be affected positively or negatively. Yet, there remains a lot more to be explored and discovered, to maximize the development of human abilities. This chapter reviews different aspects of thinking and a variety of intervention programs aimed at developing thinking skills that have been tried in various contexts, using different approaches and different subject areas. Review covers the following topics:

1) Growth and Development
2) Cognitive Development and Thinking
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Growth and Development

Childhood is considered the most fascinating period of the human life. It is quite different from adult years and sets the foundation for later years. Childhood is very important with respect to growth and development. Great resources are spent for care, development and education of children, keeping in view the importance of this period of child life. Teachers are the persons who are given the charge of new lots of children every year and are responsible for the development of all their faculties. Usually they have to deal with a homogeneous group of children that are of the same age group. The more they are aware about the children and their developmental characteristics, the better they are able to teach them. The task of a teacher is to provide the developmentally appropriate instruction to the children. The instruction should neither be too easy nor too difficult for the children. Discrete phases have been identified during childhood in which children acquire particular abilities. All human beings travel through some common routes of development. We learn to walk at the age of about one, engage in play and keep on expanding our vocabulary during childhood and become independent during adulthood. Developmental psychologists focus their attention on the patterns of development that are exhibited by all or most of the human beings (Santrock, 2006).

From conception to death, human beings undergo many changes. The orderly changes that remain for a reasonably long period of time are known as development. Development covers changes of all kinds: Changes in body structure, changes in ways individual interacts with others and changes in thinking (Woolfolk, 2004; Kalat, 2002; Papalia, Olds, & Feldman, 2001). Growth and change are important features of development (Guruge, 1979a, 1979b). Development involves growth in most of the cases...
but also includes decay like dying (Santrock, 2006). It is a multi-directional process of change that continues throughout the life span of human beings (Papalia et al., 2001). Developmental psychologists identify three major types of developments: Physical, psycho-social and cognitive (Papalia et al., 2001). Physical development includes changes in body, like growth in height and weight, development of brain, hormonal changes at puberty and refinement of motor skills. Psychosocial development includes changes in person’s relationship with others, changes in emotions and changes in personality. Cognitive development includes changes in thinking, intelligence and language. Physical, psychosocial and cognitive processes of development interact with each other to give rise the particular periods of development. Eight such periods are identified namely infancy, early childhood, middle and late childhood, adolescence and early, middle and late adulthood (Santrock, 2006).

Development of thinking pertains to cognitive development. Following section addresses thinking, cognitive development and their relationship.

**Cognitive Development and Thinking**

In literature, cognition and thinking have been used interchangeably. The term cognition is used for the mental processes with the help of which we gain knowledge and understanding (Wagner, 2009) and then apply this acquired knowledge (Reed, 2000). It includes higher-level functions of the brain that encompass attending, perceiving, knowing, remembering, understanding, imagining, thinking, judging, planning, problem solving and language (Wilson, 2000; Wagner, 2009). On the other hand, thinking is defined as the high level intellectual phenomenon that includes a complex range of mental processes of cognition, attending, perceiving, knowing and remembering (Wilson, 2000). Papalia et al. (2001) described cognitive development as the change and the stability in intellectual abilities like learning, memory, language, reasoning and creativity.
It is the development of child’s thinking and reasoning abilities (Brewer, 1995) and transition in children’s pattern of thinking (Weiten, 2001).

Thinking is a construct. There is a lack of consensus regarding the definition of thinking. We apply this term on the processes, which we can’t observe directly but can assess indirectly through actions or products. With the help of thinking, a person is better able to shape his environment as compared to mere intuition (Orlich et al., 2007).
Santrock (2006) defines thinking as manipulation and transformation of information in the memory. An ordered series of connective transactions between items of perceived information is built in this phenomenon (Kizlik, 2009). According to Baron (2004), thinking is a mental activity that is used to resolve doubt about what to do, what to believe, and what to desire. Thinking about what to do is decision making. Thinking about what to believe includes a part of learning, scientific thinking, hypothesis testing and making inferences etc. Thinking about what to desire, is similar to thinking of what to believe. Decision making incorporates both thinking about beliefs and desires and is the practical output of thinking. Thinking comprises two main parts: Search and inference. We search for the possibilities; the alternative courses of action, for the goals; the standards against which we evaluate possibilities and for the evidence; the facts about possible consequences and the probability of their occurrence. Inferences are made about correlations and contingencies (Baron, 2004). Thinking is information processing according to Siegler and Alibali (2005). When we perceive, encode, represent and store information in our brain from the surroundings, we are engaged in thinking. Perception, attention, formulating ideas, memory, use of language and symbols, remembering, imagining, creative thinking, linking different entities, understanding cause and effect relationship, predicting, planning and evaluating are the dimensions of thinking (Qualifications and Curriculum Authority, n.d.).
Components of Thinking

There are three components of thinking: Knowledge, skills and attitudes. Knowledge is important because there must be some object or content to think about it (Orlich et al., 2007). Content is not only the end but a vehicle for using thinking skills. Proper selection of content is essential because thinking skills can not be applied in empty space. They, definitely, require something to think about. Moreover, nature of content determines the selection of thinking skills that can be applied to solve the problem. Thinking skills are the fundamental cognitive functions which though are innate, can be refined through proper instruction (Costa, 2001). The examples of the thinking skills are the ability to perceive a problem, to gather relevant information, to organize them, to analyze them and to communicate the results. The examples of attitudes or thinking dispositions are the curiosity and tolerance for ambiguity, and they also have very important role in thinking (Orlich et al., 2007). Dispositions for thinking play a decisive role in thinking and determine whether the person will use thinking skills when they matter (Perkins & Tishman, 2009). Thinking dispositions are the habits of mind that stimulate the phenomenon of thinking. Persistence, deliberateness, thinking problems from various angles, asking questions, thinking about one’s own thinking, linking previous knowledge for solving the problem in hand, using all senses for the collection of information, enjoying thinking endeavor, taking risks with responsibility, attitude towards continuous learning, listening for understanding and thinking interdependently, using clear and unambiguous language - both in thinking and communication and striving for accuracy as well as precision are the examples of thinking dispositions (Costa, 2001). A reasonable thinking skill program includes an additional component besides the above mentioned three components of thinking. Thinking skill programs comprise the properly selected content, thinking skills, thinking dispositions and challenging tasks. A
challenging problem or situation with no clear answer is required for the thinking skills to be applied (Costa, 2001).

**Thinking Skills**

Skills for kids can be categorized into four main kinds namely physical, social, emotional and cognitive. Cognitive skills are those that are related to thinking and learning (“play”, 2009). There is a lack of agreement regarding the definition and constituents of thinking skills. The reason is that, it is difficult to describe thinking skills like motor skills (Wilson, 2000). Thinking skills are the key cognitive skills with the help of which reasoning, learning and problem solving become possible (Qualifications and Curriculum Authority, n.d.). McGuinness (1999) includes collecting, sorting and analyzing information, drawing conclusion based upon this information, determining cause and effect, decision making, problem solving, brainstorming, planning, evaluating, monitoring and reflecting on ones own progress as the dimensions of thinking skills.

Thinking skills are simple and particular cognitive functions or the "building blocks" of thinking. Recalling, comparing, classifying, inferring, generalizing, evaluating, experimenting and analyzing are the examples of the thinking skills. A somewhat intricate sequence of thinking skills constitutes a thinking process. These are larger mental operations that require a number of thinking skills to be operated. Thinking processes are broader and directed towards achieving a particular goal (Marzano et al., 1988; Costa, 2001; Kizlik, 2009). Kizlik (2009) and Marzano et al. (1988) identifies the following eight main categories of thinking skills:

**Focusing skills.** These skills include attending to the relevant bits of information and ignoring the other pieces of information. Goal setting and carefully defining the problem are included in focusing skills.

**Information gathering skills.** This group of thinking skills includes collecting
relevant data through senses and inquiry and making it available for cognitive processing. Observation and questioning skills are included in information gathering skills.

**Remembering skills.** Encoding and recalling are included in the remembering skills. These include storing information into long term memory and then retrieving it from long term memory.

**Organizing skills.** These skills involve arranging the information so that it can be used effectively. These include comparing the entities, classifying the entities on the basis of characteristic, ordering entities according to some criteria and representing i.e. changing the form without changing the essence of information.

**Analyzing skills.** This category of thinking skills includes examining the information by judging the parts and relationships. It includes identification of the component, characteristics, main ideas, patterns, relationships and errors.

**Generating skills.** This category of thinking skills involves creation of new information, meaning or idea. Elaborating, predicting and inferring are included in this category of thinking skills.

**Integrating skills.** This category of thinking skills involves connecting and combining information. It includes summarizing and restructuring; changing the existing organization of knowledge to incorporate new information.

**Evaluating skills.** This category of thinking skills involves judging the rationality and quality of ideas, on the basis of criteria. Development of criteria and Verification of the accuracy of statement are included in this category of thinking skills.

Concept formation, knowledge generation, reasoning, critical thinking, creative thinking, decision-making and problem solving are the thinking processes that incorporate a series of thinking skills (Nickerson, 1988; Costa, 2001; Santrock, 2006; Kizlik, 2009). Reasoning is the use of logical thinking to reach at some conclusion. It may
be inductive or deductive. Inductive reasoning proceeds from specific to general and is used in concept formation. When we draw conclusions about all members of a category based on the observation of some of the members of that category, we are engaged in inductive reasoning. Deductive reasoning is the opposite of inductive reasoning; it begins with the general and ends with the specific. Creative thinking is the ability to think in distinctive and novel ways and to produce several alternatives. With the help of creative thinking a person can deal with the problems with unique and better solutions. Critical thinking is the reflective, productive and evaluative thinking. Dewey (1933) was the proponent of reflective thinking. Presenting controversial issues to students, asking ‘how’ and ‘why’ questions and expecting alternative explanations rather than one correct answer are essential for building critical thinking among students. Decision making involves both critical and creative thinking. It includes generating several alternatives, evaluative them and choosing the best one among them. Problem solving involves identifying and clearly formulating the problem, developing strategies for solving the problem, evaluating the alternative strategies, continuously re-thinking and re-defining the problem and improving the solutions while learning from the past experiences (Santrock, 2006).

**Mechanism of Cognitive Development**

The research of Swiss cognitive psychologist Jean Piaget contributed immeasurably to our understanding of the cognitive development. Lev Vygotsky is the other prominent name in this field. Piaget described the mechanism and the stages of cognitive development whereas Vygotsky emphasized the role of society and culture in the development of thinking skills and cognitive processes. LeFrancois (1999) describes that Piaget sees development as unfolding of internal tendencies, whereas Vygotsky perceives the development as the result of interaction with other people. Mechanism of cognitive development, its stage and the factors that affect the cognitive development are
discussed in the current and the following sections.

To understand the mechanism of cognitive development, it is necessary to understand the concept of cognitive structures: The schemata and cognitive functions: Assimilation and accommodation. Each child is born with a natural tendency to interact and make sense of his environment. Child interprets and processes the information collected from his environment into ‘cognitive structure’ that are known as schemata (Slavin, 2000). A schema (pl. schemata) (Shayer & Adey, 2002) is not accumulation of knowledge but is a way of thinking (Docstoc, 2009; Shayer & Adey, 2002). Schemata are basic conceptual frameworks and organized pattern of thought or action that allow the person to mentally represent and ‘think’ about the events and objects of the world (Woolfolk, 2004). Physical and mental are the two main types of schema. A child is born with a limited number of physical schemata that are sensory or motor in nature. The examples of schemata a child is born with are: Looking, hearing, tasting, touching and grasping. Mental schemata are developed as the child interacts with the environment. Both physical and mental schemata continue to develop throughout the life span of a human being (Bee & Boyd, 2004). Schema can be used in different situations (Papalia et al., 2001). They may be simple or complex. Development in thinking is possible through change in schema (Santrock, 2006)

Schemata undergo two simultaneous and complementary cognitive functions namely assimilation and accommodation, which result in change in their structure. Assimilation occurs when external data is interpreted in terms of individual’s existing cognitive structure or schema. Accommodation involves adjusting or changing existing cognitive system in order to incorporate or accommodate external data (Flavell, Miller, & Miller, 1993). Functions of assimilation and accommodation continuously operate like oscillations of pendulum to maintain a balance between cognitive structures and
environment. The balance between cognitive structures and environment is an ideal state and is called equilibrium. At the state of equilibrium, a person has a fairly good understanding of his environment (Boeree, 2009).

When children encounter the experiences that can’t adequately be explained in terms of their current understanding, imbalance between current understanding and new experience creates mental discomfort that is called disequilibrium. By using Cognitive functions of assimilation and accommodation, they re-gain equilibrium. The movement from equilibrium to disequilibrium and back to equilibrium is known as Equilibration. The process of equilibration promotes progression towards increasingly more complex level of thinking (Ormrod, 2000). Learning depends on the process of equilibration as it involves thought restructuring (Slavin, 2000).

Children represent their understanding about the world through schema. They try to assimilate any new information about the world in these schemata. The process continues till too much contradiction is created between the new information and existing schemata. This contradiction requires a change and restructuring of schema and re-equilibration of the child’s view about the world (Lourenco & Machado, 1996).

According to Piaget (1978), the process of equilibration gives rise to the stages of cognitive development. Bee and Boyd (2004) illustrated the mechanism of cognitive development with the analogy of a map. Imagine that a person has to move through a new city with a hand drawn map given to him by some friend. During his journey, the person makes some corrections and takes some notes on the map. Corrections and annotation continue till a time comes when the person considers that his existing map is seriously flawed and feels the need to draw a new map. This new map is definitely better than the original version, but still requires corrections on it. A time comes when the person redraws it again. Modifications continue again and when the third map is full of
annotations, the person draws the fourth one. Corrections and annotation are analogous to accommodation and the process of starting over and drawing a new map is analogous to equilibration in Piaget’s theory. Each modification of the existing map or redrawing a new map helps the person to more easily assimilate his journey though the city.

According to Piaget, initially a child starts his journey like the person with primitive map. When inadequacies in the cognitive structures are encountered, a major change in schema is resulted. A child experiences three major reorganizations or equilibrations in his life, leading the child towards a new stage of cognitive development. The first major reorganization occurs at the age of 2, when child shifts from the simple sensory and motor schema to the use of symbols. Second major reorganization occurs at the age of 6 or 7, when a complete set of new powerful schema are added to the repertoire of child. These new mental schema were called *operations* by the Piaget. Third major reorganization takes place at the age of 11 or 12, when child can *operate* not only on concrete events and objects but also on abstract ideas. As a result of these major reorganizations, four stages of cognitive development appear (Bee & Boyd, 2004) which are discussed in the following section.

**Stages of Cognitive Development**

According to Piaget, thinking of a person changes qualitatively from birth to adulthood. Qualitative differences in thinking and cognitive processes give rise to four distinct stages of cognitive development (Lin, 2002; Huitt & Hummel, 2003). The important aspect of these stages is that, their sequence is universal (Piaget's, n.d.).

The stages are the following:

1. Sensory motor stage (Birth to 2 years)
2. Pre-operational stage (2–6 or 7 years)
3. Concrete Operational stage (6 or 7 years to 11 or 12 years)
4. **Formal Operational stage (11 or 12 years through adulthood).**

During sensory motor stage, child engages in intentional and goal directed behavior. Goal-directed behavior and object permanence are the major achievements of child during this stage (Oswalt, 2006).

Thinking of early school children may range from pre operational to concrete operational stages and hence these two stages are elaborated below.

**Pre operational stage (2–6 or 7 years).** At this stage, child can symbolically represent in mind the events and objects that are not present and can use primitive reasoning. However she lacks operational thinking. This stage is further divided into two sub-stages: *Symbolic function* sub-stage and *intuitive thought* sub-stage.

**Symbolic function sub-stage.** This sub-stage lasts from 2-4 years. Simple but strong symbolism appears in children during this sub-stage. It reveals in the form of expanded use of language and pretend play. In the imaginary world of children, skies may be brown and cars might be in clouds. *Ego-centrism* and *animism* are the two main limitations at this sub-stage. Ego centrism is the inability of the child to distinguish that others perspective might differ from her own perspective. Animism implies the belief of the child that non-living object also have the characteristics that the living beings have and are capable of actions (Santrock, 2006).

**Intuitive thought sub-stage.** It lasts from 4-6 or 7 years. Children try to answer all types of questions using primitive reasoning but they don’t know how they know what they know. The main limitation at this sub-stage is *centration* i.e., the children can focus their attention on one aspect at a time ignoring all other characteristics of something. For example, they are struck either by the height or width of the liquid in the container. This limitation is associated with the lack of *operations* (Berger, 2001; Santrock, 2006), which are the organized, integrated and reversible systems of mental processes (Ormrod, 2000),
and are the main feature of the next stages.

**Concrete operational stage (6 or 7 years to 11 or 12 years).** At concrete operational stage children can think in more quantitative way. They can go beyond the surface appearance to the underlying reality (Flavell et al., 1993; Anderson, 2000). Children get the ability of *decentring* i.e. they can equitably distribute their attention to all important elements or dimensions of some task or object (Woolfolk, 2004). They are able to coordinate information about various aspects. Children are able to solve problems related to concrete phenomena using logical reasoning instead of intuitive thinking. However they can’t solve abstract problems. They are able to use concrete operations, the reversible mental actions pertaining to real objects (Santrock, 2006). Some concrete operations are elaborated below:

**Conservation.** This is the concrete operation due to which child is able to realize that certain characteristic of an object remains the same despite the change in its other properties. For example if we pour some liquid from a wider container to a tall narrow container, the amount of the liquid remains the same despite the change in appearance or shape (Santrock, 2006; Slavin, 2000). Children at concrete operational stage are able to reason out about transformations (Ormrod, 2000).

**Reversibility.** Reversible thinking is the ability to think through a series of steps, then mentally reverse the steps and come to the original point (Woolfolk, 2004). For example child is able to think that 3+4=7 and then he is able to think in back ward direction that 7- 4=3. In the example of pouring liquid from wider container to tall narrow container, she is able to think in reverse direction and appreciates that if the liquid is poured back into the wider container, it would be the same (Slavin, 2000).

**Compensation.** This is the concrete operation due to which child is able to recognize that change in one direction can be compensated or balanced for the change in
another direction. In the example of pouring liquid from wider container to tall narrow container, child would be able to recognize that though the liquid rose higher in the container but the container was narrower (Slavin, 2000).

**Classification.** This concrete operation allows the child to categorize objects into groups and sub-groups based on some characteristic (Woolfolk, 2004).

**Class inclusion.** This is the concrete operation due to which child is able to think simultaneously about a whole class and subordinate classes to be able to recognize the relationship between the whole class and its subordinate classes. Children at concrete operational level are able to think and recognize that a person or object can be a member of the whole class and subordinate class at the same time (Slavin, 2000).

**Seriation.** This concrete operation involves ordering stimuli or objects according to some quantitative dimension (Santrock, 2006). For example, arranging objects in increasing or decreasing order on the basis of some characteristic like length, weight and volume call for the use of schema of seriation (Slavin, 2000).

**Deductive reasoning.** Children at concrete operational stage can use deductive reasoning and are able to draw inferences from the given facts (Ormrod, 2000). They can logically combine the relations of concrete events and problems to draw inferences. For example if \( A > B \) and \( B > C \), the child is able to recognize and infer that \( A > C \). This becomes possible with the help of *transitivity* (Santrock, 2006), which in turn involves two reversible mental transformations namely inversion \( (+A \) is inversed by \(-A\) \) and reciprocity \( (A < B \) is reciprocated by \( B > A \) \) (Slavin, 2000).

Following section addresses the factors that affect the Cognitive Development or the development of thinking.

**Factors Affecting Cognitive Development**

According to Adey & Shayer (1994), there are three factors that affect cognitive
development namely heredity, maturation and environment. Heredity is the genetic make-up of a person that he acquires from his biological parents. It is the inborn influence on the development. Maturation is the natural and usually age-related unfolding of genetic influence. Physical and behavior patterns are uncovered in particular sequence under the process of maturation. Readiness to master new abilities such as walking and talking are the examples of such patterns. Environment is absolutely the non-genetic influences on the development, external to the self. It ranges from the pre-natal environment to the environment after birth throughout the life. Family, neighborhood, socioeconomic status, ethnicity and culture are the constituents of the environment. Experiences and conditions surrounding the individual are included in this factor (Papalia et al., 2001). The current section addresses biological and environmental factors that affect the cognitive development.

Cerebrum, also known as the thinking cap covers most of the upper and front part of the brain and is believed to be linked with higher thinking processes. There is a two-way relationship between the physiology of cerebrum and thinking processes. On one side, connections within it are inevitable for higher level thinking processes. On the other hand, these connections are formed when they are stimulated. The more the stimulus is provided, the more connections are formed (Wilson, 2000). Experience plays a key role in the formation of synaptic connections. Neurons and synapses compete for survival and only those neurons and synapses survive that are used, whereas unused ones disappear or prune (Santrock, 2006; Diamond & Hobson, 1998).

Biological events, along with environmental factors contribute towards the cognitive development (Epstein, 1999 a, 2001). Epstein (1980, 1986) suggested the idea and then defended it (Epstein, 1990) that brain grows in the phases of spurts and plateau rather than symmetrical growth over time. Weight of brain increases 5-10 % during the
brain spurt phase; whereas increase in weight is around 1% during the plateau phase (Epstein, 1999a). Five brain spurt stages are identified experimentally, which are 3-10 months and 2-4, 6-8, 10-12, and 14-16 years (Epstein, 1999a). These phases of spurts account for the biological bases of Piaget’s stages of cognitive development (Epstein, 1999a, 2001).

According to Epstein (1999b), brain growth spurts are linked with the increased amount of cerebral blood flow (CBF) which provides required materials and energy for the growth of brain. Rapid brain growth appears immediately after the increased cerebral blood flow. Brain growth spurts are associated with the growth of dendrites that lead towards increased wiring in response to stimulating experience. Life experiences contribute towards strengthening, weakening or modification of the neural network (Epstein, 1999a). This suggests the need of instruction for high order cognitive functions (Epstein, 1999a; 2001).

It is very important to provide intellectually stimulating environment to the children at the right time so that we can enhance their intelligence and accelerate their cognitive development. Stimulating experience provided during the critical periods of brain growth spurts leads towards the development of new neuronal connections. Intervention provided immediately after the brain growth spurts proves to be the most effective. Interventions provided during plateau were found to be relatively ineffective. During the plateau, it is difficult to give new concepts to children. Instead, it is the phase in which consolidation of already acquired concept is possible (Epstein, 1999a).

Environmental influences on the cognitive development can be categorized into two main spheres: Physical and socio cultural. Both physical and socio cultural environment has crucial role in the cognitive development. Importance of physical environment was recognized by Piaget (Ormrod, 2000) and that of socio cultural
environment by Vygotsky.

Piaget believes that active interaction with physical world is indispensable for the development of thinking skills. According to Piaget, children learn best when they are active and search the solution of the problem by themselves (Santrock, 2006). Cognitive development is mostly individual endeavor according to Piaget. Piaget emphasizes on active interaction with the physical environment and considers it necessary for the development of thinking. The reason is that the progression of a child from a lower level of thinking to a more complex level of thinking is possible only through the process of equilibration (Ormrod, 2000). It is through the variety of experiences that children encounter the situations which they can’t explain with the existing level of thinking. Through change and reorganization in their existing mental structure, they try to remove their disequilibrium and meanwhile gain higher level of thinking.

The role of social interaction in cognitive development is recognized by Vygotsky (1978). He gives a different explanation of the cognitive development by emphasizing the crucial role of society and culture. According to him, individuals of society can play a key role in the cognitive development of the children. According to him, each person has two levels of cognitive development: Actual level and the potential level. Actual level is the point up to which the person can perform some task independently, whereas the potential level is where the person can’t perform the task alone, but can perform it if support is provided to him by some more able peer or elder. Vygotsky names the difference between the two levels, actual one and the potential one as Zone of Proximal Development (ZPD).

Vygotsky recognizes that children learn very little while performing the tasks they already can perform independently. For thinking skills to be developed, children should be provided with the tasks within their zone of proximal development. Operating on the
challenging tasks in collaboration with some more able peer or adult maximizes the
cognitive development of the children. Individuals and institutes of society can help the
children reach their potential level through guided participation and scaffolding. Children
should be provided with the tasks within their ZPD and then the required assistance
should be provided to them while performing these tasks (Ormrod, 2000). Contextual
approach of Vygotsky connects the social and cognitive spheres with each other (Flavell
et al., 1993).

Vygotsky highlights the importance of social interaction for the progression
towards next higher level of thinking. According to Vygotsky (1978), when children
think with each other or with the help of others, soon they become able to think in the
same manner independently. However, like other constructivists, Vygotsky stresses on
the active role of learners in development of their own thinking (Wilson, 2000).
Vygotsky’s (1962) socio cultural aspect of learning includes both scaffolding and active
participation of learner in the process of collaboration with others.

**Developing Thinking**

All the human beings do think because it is the intellectual thinking that
distinguishes *Homo sapiens*, ‘human, the intelligent’ from the rest of the living beings
(Anderson, 2000). All of us do think, but all type of thinking is not required and is not
valued equally. It is the quality of thinking that counts the most. The focus of the
educational system should be to develop and extend the thinking skills, to develop the
thinking at a qualitatively higher level and to move it into elevated gear (The Open
University, n.d.).

Twentieth century represents two different traditions regarding cognitive capacity
of the human being. Until 1960s, the notion of fix and innate intelligence dominated the
educational practice (Nisbet, 1990). The belief that children have measurable fixed
intelligence that can’t be developed, must be challenged (Wilson, 2000) and it was
called first time by Vygotsky (1962). The impression of fix intelligence was further
intelligence, which suggests that there are many types of intelligence. Each type of
intelligence involves unique cognitive skills. By teaching these thinking skills, different
types of intelligence can be developed. According to Gardner, eight different types of
skills namely verbal, logical-mathematical, linguistic, musical, spatial, kinesthetic,
interpersonal and intrapersonal contribute towards intelligence. By the end of twentieth
century, a move was aroused for the development of some core skills like problem
solving and decision making among the students with the help of which they are better
able to cope with the life challenges (Wilson, 2000).

Previously cognitive capacity was considered to be somewhat static that is
governed biologically. Now, however, it is believed that it comprises some tools that can
be given to the learners (New Horizons for Learning, 2006). Lefrancois (1999) suggests
that cognitive processes that we use in thinking are like the box of tools through which
we play the game of cognition. We may have different tools in our box but we can
improve the way in which we use these tools. Intelligence is the innate intellectual power,
but thinking is the skilled use of the intelligence (Hamers & Csapo, 1999). In other words
thinking can be nurtured and taught through training and proper environment. If thinking
can be taught, and we don’t try to develop it, then we are demolishing the cohort of
students whose thinking is less than what it can be (Nickerson, Perkins, & Smith, 1985).

Intelligence and thinking skills tradition assume different views regarding
cognitive development. Intelligence tradition considers that intellectual abilities develop
gradually. Intellectual capacity remains somewhat fixed for a person and the standing of
the person in the society doesn’t change with the age. Quality of experience doesn’t seem
to matter much for the intellectual capacity of the person. In contrast, thinking skill
tradition identifies that many of the skills that are usually believed to be associated with
the intelligence are teachable. This tradition believes that thinking skills can be developed
just like motor skills. For this purpose, two conditions are important, conscious effort on
the part of person concerned and practice. When thinking skills are developed among the
children, educational standards are also raised. But the tradition believes that we can get
these results when thinking skills are taught directly and overtly. Critical thinking and
problem solving traditions are among the strands of thinking skills tradition (Fisher,
2005).

**Need and Justification of Developing Thinking Skills**

The idea of teaching thinking is not new (Nisbet, 1990). For Greeks, it was the
prime aim of education. Traditional logic and Socratic dialogue were necessary for this
purpose according to Plato (Wilson, 2000). In ancient Greek civilization, mathematics
and philosophy were taught to the students with the conviction that even if they are not
becoming mathematicians or philosophers, these subjects would sharpen the minds of
students and in turn they would be able to perform any task in a better way. During recent
several years, there is a resurgence of the idea that we should teach thinking skills to the
children in the schools (Baron, 2004). Educators are recognizing that one of the most
important goals, the education and schools should serve is to enable the students as
responsible and independent thinkers (Kuhn, 2005). There is an increasing concern of
teaching thinking throughout the world because all societies consider these crucial for
continuously being proficient in fast-paced and competitive world (Lang, 2006).

Following are the reasons which justify the need of developing thinking skills
among the students:

1. Realm of knowledge has been developed enormously just like the tremendous
growth of human population. Body of knowledge has been developed over thousands of years across several fields and disciplines (Baron, 2004). Knowledge becomes double after every eighteen months (Russell, 1998). It is very difficult to estimate how much knowledge will be required in future (Fisher, 1999). The ‘banking theory’ of knowledge based upon rote learning has been discarded. Individuals cannot accumulate sufficient knowledge in their memories (Wilson, 2000). No person can have a command over the continuously increasing body of knowledge. One can master only a small fraction of useful knowledge (Baron, 2004). Moreover, the existing knowledge, concepts and models become obsolete very soon due to the extraordinary change in the world (Walker & Finney, 1999; Whatley & Loren, 1999). This is especially true for continuously growing scientific knowledge (Venville, Adey, Larkin, Annne, & Hammersmith, 2003). In the upcoming time, this trend will carry on. However, what an educational system can do and it should do, is to enable the students to learn how they should know what they need to know (Baron, 2004) and to shift its focus from imparting information to teaching and helping the children to think and learn for themselves (Fisher, 1999).

2. Knowledge deals with knowing what and skills deal with knowing how (Walker & Finney, 1999), but thinking skills involve both knowing what and knowing how (Wegerif, 2002). The quality of our learning and our lives depend largely on the quality of our thinking (Fisher, 1999). Thinking skills are crucial for learning about the surroundings and for competing in future that will be increasingly technological and scientific (Brothers, 1999). Complexity of modern job requires the individuals to be equipped with such skills with the help of which they can generate new knowledge and processes. Thinking skills are indispensable for the
students to cope with diverse situations in various contexts at various times and to deal with the demands and challenges of the swiftly changing world (Wilson, 2000; Beyth-Marom, Novik, & Sloan, 1987; Wong, 2007).

3. Modern society calls for active citizenship. For this purpose, individuals should be able to incorporate knowledge from multiple sources and then make sound judgment (Wilson, 2000). Thinking skills are inevitable to understand the world and are equally important for individuals and society (“Scientific”, 2000). Dewey emphasizes that the role of education in a democratic society should be to enable the individuals to think about things that affect them and others in the society (Baron, 2004).

4. When thinking skills are developed, academic achievement is also enhanced. Improving the quality of thinking raises the educational standards as well as prepares the children for life long learning (Fisher, 1999; Wilson, 2000). Three R’s of reading, writing and arithmetic must be supplemented with forth R, reasoning. To raise the educational standards, teaching thinking and reasoning is central even in the most basic skills of curriculum (Fisher, 1999).

Until recently it was assumed that students who attend formal institutes of higher education would have thinking skills due to learning environment which they receive over there (Al-Fadhli & Khalfan, 2008). But it was not the case. Nearly all those who contributed towards the development of thinking skills, noticed some deficiency in the thinking skills of their students. Thinking skills intervention were developed to address the deficiency in thinking skills of the students (Fisher, 2005).

Teaching thinking skills also requires change in the role and relationship between the student and the teacher. From the traditional role of teacher, as a source of knowledge, it requires the teacher as a co-learner with the students (Wilson, 2000). Role
of teacher shifts from the one who delivers declarative and procedural knowledge to that of a coach who helps the children to acquire the skills necessary in the competitive world (Meyer, Haywood, Sachdev, & Faraday, 2008).

Thinking can be taught to the children through thinking skills intervention programs. Given below is the description of thinking skills intervention programs that have been tried out in the world.

**Thinking Skills Development Programs**

Thinking skills interventions are approaches or programs which recognize that there are some transferable, teachable mental processes for individuals. They require individuals to sketch, explain and assess their thinking and learning. A thinking skills approach states not only what is to be taught but also how to be taught (Higgins et al., 2005).

Thinking skills interventions may be domain specific or domain general. Domain specific intervention programs assume that cognitive skills are context bound. What is learnt in one context or domain can be applicable for performing the tasks in the same domain or context. It assumes that teaching thinking skills may lead towards the development of thinking skills in the same context. Domain general intervention assumes that there is a general processing mechanism of mind, which controls all mind functioning and all intellectual domains. All experiences a person gains are fed into this general processor and contribute towards its development. Development of this central cognitive processor results into the enhanced intellectual activity in all subject domains. Domain general intervention programs assume that thinking is a generalized skill that is transferable from one domain to other domains as well. Teaching thinking in one domain leads towards the development of general processor which is then available for the enhanced performance of tasks in a variety of contexts (Adey & Shayer, 1994; Wegerif,
During last several years, thinking skills intervention programs have been extensively used around the world. Higgins et al. (2004; 2005) conducted meta-analysis of the thinking skills intervention programs. Meta-analysis is a research technique developed by Gene Glass (Glass, McGaw, & Smith, 1981) in the mid-1970s, which statistically summarizes the results of a large number of studies to find out their average effect (Boston, n. d.). Meta-analysis study overviews the comparative effect of several studies in quantitative terms and hence gives an exact picture of their effects (Higgins et al., 2005). An effect size of 0.20 is considered as small, 0.50 as medium and 0.80 as large (Cohen, 1988). These meta-analysis studies are discussed here to have an overview of the thinking skills intervention programs conducted across the world.

In initial study, nearly 6500 potentially relevant chapters and studies from electronic data bases were identified and screened. Through the use of systematic map, 191 studies were included in the meta-analysis. Among those, 23 studies that used a combination of both qualitative and quantitative analysis were analyzed in detail (Higgins et al., 2004). In the second meta-analysis study (Higgins et al., 2005), in-depth analysis of 29 studies were carried out, 26 of which were obtained from first review (Higgins et al., 2004) while rest of the 3 were obtained from the updated searching. Those studies were included in the meta-analysis, which have a control group and adequate data to compute effect size. Moreover, minimum sample size of 10 was decided as criteria to be included in the meta-analysis. These studies were conducted at the primary and secondary level of schooling with the age of participants ranging from 5-16 years.

It was revealed that the thinking skills interventions were effective for improving students’ performance on various dimensions. Effects of thinking skills interventions were studied on three main dimensions: Cognitive, curricular and affective. Meta-
analysis study revealed that average effect size of thinking skills intervention programs was $0.62 \sigma$ on cognitive dimension, $0.62 \sigma$ on curricular dimension and $1.44 \sigma$ on affective dimension (Higgins et al., 2005).

Different approaches that have been used for the development of thinking skills are discussed in the following section.

**Approaches for Developing Thinking Skills**

Any skill development program has some theoretical background and the effectiveness of the program is linked with the quality of its theoretical background (Legacee, 2009). Nisbet (1990) categorizes teaching thinking skills programs into two main approaches; infusion approaches that teach thinking skills through the existing curriculum and specifically designed stand alone programs that are introduced parallel to the existing curriculum. McGuinness (2005) labeled them as infusion and enrichment approaches. Out of 191 studies reported by Higgins et al. (2004), 106 were related to infusion approaches, whereas 60 were related to enrichment approaches. These approaches are narrated below:

**Infusion approaches.** McGuinness (1999) further divides the infusion approaches into two groups: Across the curriculum infusion approaches and thinking skills embedded into some particular subject like science, mathematics, history and geography. Evaluations for thinking skills programs across the curriculum or embedded into subjects are less well-documented (Wilson, 2000). Types of infusion approaches are briefly narrated here.

**Across the curriculum infusion approaches.** Infusion approaches are the collection of those examples where thinking development is infused and embedded in and through existing curriculum. Across the curriculum infusion model usually focuses more on the affective dimensions and goes beyond the development of cognitive skills and
abilities (McGuinness, 2005). Activating Children’s Thinking Skills (ACTS) is an example of across the curriculum thinking skills approaches. In this project, thinking diagrams are produced to explicitly present the steps of thinking before the children. It was designed by McGuinness et al. (1997).

*Thinking skills embedded in particular subject or domain.* In subject specific approach, thinking skills are embedded in some traditional curriculum subject like mathematics, history, geography, reading and writing.

Some subjects like mathematics have long been associated with thinking (Wilson, 2000). It is contended that the focus of teaching mathematics should be the skills required to solve the mathematical problems rather than seeking the answers per se (McGuinness, 1999). Similarly, since 1960s, a shift has occurred from teaching historical facts per se to deriving broad themes, concepts, historical inquiry and understanding in the history. There is an increasing trend that thinking skills like collecting evidence, analysis and interpretation should be embedded in the subject of history (Wilson, 2000) and the students should be trained to think like historians (McGuinness, 1999). Thinking through geography designed by Leat (1998) was an example of domain specific thinking skill program. A list of big concepts of geography was identified as the concepts necessary for the understanding of geography. Lessons developed by Leat focused on the development of these concepts.

**Enrichment approaches.** These are specially designed programs of intervention that focus on the development of general thinking ability. They are organized in parallel with the existing curriculum arrangement (McGuinness, 2005). For these programs, separate time is allocated in the time table. Some of the enhancement programs are as follows:

*Instrumental Enrichment (IE).* Instrumental Enrichment is among the most
extensively researched programs of thinking skills (Higgins & Hall, 2004). It is a content-free cognitive intervention. It was developed by Reuven Feuerstein (Feuerstein, Rand, Hoffman, & Miller, 1980) for the under-achieving and learning-disabled Israeli adolescents to improve their self-concept, motivation, and intellectual ability. The intervention comprised 14 increasingly demanding instruments to be used over the time of 2-3 years. Though this program was developed for the disadvantaged persons some of which were victimized during and after Second World War, the program is used now with the individuals of various age and ability groups, generally with positive results (Fisher, 2005). The focus of Feuerstein was on the development of fundamental skills like comparing and classification. The work of Feuerstein has a prominent place in the area of thinking skills intervention programs and stimulated many other thinking skills interventions. Somerset thinking skills course is among these (Higgins et al., 2004) which is described below.

**Somerset thinking skills course.** Somerset Thinking Skills Course is a general thinking skills program devised by Blagg, Ballinger, and Gardner (1988). Blagg developed this course by making amendments in Instrumental Enrichment. Unlike Instrumental Enrichment which focuses on abstract concepts, Somerset Course is pictorial and naturalistic. It can be used as stand alone or across the curriculum intervention. It can be used with the children of upper primary classes or with the mixed ability secondary class children (Wilson, 2000).

**Cognitive Research Trust (CoRT) _ de Bono.** Edward de Bono emphasized that practicing some strategies consciously is necessary for becoming an effective thinker (de Bono, 1970, 1992). CoRT material developed by de Bono presents thinking tools to the children. He encourages the students to think from various angles and then make some decision (Higgins et al., 2004). Focus of de Bono is on divergent or ‘lateral thinking’
Fisher, 2005). His lessons encourage learners to stop in the middle of the lesson and imagine the views of others engaged in that situation. CoRT consists of six sections, each of which comprises 10 lessons. Each section covers one aspect of de Bono’s definition of thinking: Breadth, organization, interaction, creativity, information and feeling, and action. Edward de Bono has written more than fifty-six books on teaching thinking. He introduced that while solving some problem, we may have different types of thinking (Wilson, 2000). Thinking tools like six thinking hats were introduced by him. These are hypothetical hats with white, black, yellow, red, green and blue colors, each of which represents thinking with a different angle regarding the same problem or topic. Hat with white color represents facts, red is for emotions, green for imagination, black for negative aspects, yellow for positive aspects and blue for reflective thinking and meta cognition. Thinking hats have been used by many schools to enable the students to think laterally. All members of the group wear each hat one by one and experience different kinds of thinking regarding the same problem. Children are encouraged to reflect which hat they are wearing and also to vary their hats (Wilson, 2000; National Literacy Trust, 2009).

**Philosophy for Children (P4C).** This model was designed by Lipman (Lipman, Sharp, & Oscanyan, 1980; Lipman, 1981, 1991) and was further developed by Fisher (1995, 1998) in UK. Now it has been adapted in many countries (Fisher, 2003). Lipman started this program because he was discouraged to see that many of his students even at university level were unable to demonstrate some basic thinking skills like building argument and viewing things from various perspectives. He believed that it is very difficult to develop thinking skills at this level. So he started the program *Philosophy for Children (P4C)* for the children of age 5-15 (Fisher, 2005).

Asking and answering questions is at the heart of developing thinking skills. Questions may be the starting point for the whole areas of study. The question of the
Newton ‘Why apple falls to the ground?’ was one of such examples. Questions produce a desire to know the situation and solve the problem (The Open University, n.d.). Putting questions worth pursuing are important for developing thinking skills in students (Pithers & Soden, 2000). Lipman believes that children are the natural philosophers that constantly ask questions and remain in search of answers to these questions. Reasoning patterns of argument and discourse, exploration, questioning and Socratic dialogue is emphasized in P4C. According to Fisher (2007), P4C develops critical thinking; the power to deduct from various texts and the creative thinking; the ability to generate hypothesis among children. This is done through the dialogue between children and teacher as well as dialogue among children. The capacity to question is central to intelligent behavior and P4C tries to sustain and develop this ability among children. With the help of Socratic dialogue, children are engaged in progressively higher level of thinking; from literal (factual) to analytical (creative and critical) and then to conceptual (abstract) thinking.

Cognitive Acceleration. Cognitive Acceleration is a context dependent domain general cognitive intervention program. According to McGuinness (2005), Cognitive Acceleration is the most successful cognitive enrichment program for the development of students’ general thinking ability. Unlike philosophy for children (P4C) which focuses on deductive reasoning and moves from general to specific, Cognitive Acceleration is based upon the inductive reasoning and leads the children to move from concrete examples to abstract generalizations (Wilson, 2000). Cognitive Acceleration was developed upon the theoretical foundations of Piaget and Vygotsky (Shayer, 1999). The current study uses cognitive acceleration approach for developing thinking skills of children.

Like other developing thinking skills programs (Fisher, 2005), Cognitive Acceleration was developed when some deficiency in cognitive ability of students was
observed. Cognitive Acceleration originated when evidence came forth that children are lagging behind the developmental expectations as proposed by Piaget. “The Concepts in Secondary Mathematics and Science” (CSMS) survey conducted for six years in UK, revealed that fewer than 30% of age 16+ students showed the use of even early formal operational stage. Hence, majority of the students leaving the school were using only concrete operational level (Adey & Shayer, 1994). Similarly, at the age of 10, children should be at late concrete operational level, but only 40% children of this age showed late concrete operational level. The age at which 90% of the children attained this level was found to be the 15 years old (Shayer & Adey, 1981). Thinking skills interventions started in early 1980s in UK schools (Higgins et al., 2005). Adey and Shayer identified the need to intervene the cognitive development of children so that they can meet the cognitive developmental expectations and exhibit higher-level thinking (Adey & Shayer, 1994).

The current study was conducted using the conceptual framework of Cognitive Acceleration. Hence the conceptual framework is described in the following section.

**Conceptual Framework of Cognitive Acceleration**

Cognitive Acceleration is among the thinking skills interventions that work from the field of psychology (Fisher, 2005). The foundation of Cognitive Acceleration is built on Piaget’s stage theory of cognitive development (Higgins et al., 2004). According to Shayer (1999), Cognitive Acceleration owed almost equally to the ideas of Piaget and Vygotsky. It actually speeds up the transition of children from one stage of cognitive development to the other using the Vygotsky’s ideas. Adey & Shayer (1994) suggested that Vygotskian aspect can be considered as engine whereas Piagetian aspect as gearing of the Cognitive Acceleration that demands that right match should be there between intervention provided and the cognitive ability level of the children. Cognitive
Acceleration also uses the principles of Feuerstein (Adey & Shayer, 1994; Higgins et al., 2004). Cognitive Acceleration is an *intervention* that is different from the *instruction*. Instruction focuses on *learning* and the transfer of knowledge. On the other hand, intervention provided by Cognitive Acceleration works on the *development* of child’s general cognitive processing capability in such a way that the child can benefit from instruction in any field (Adey & Shayer, 1994).

Higgins et al. (2005) reported four studies on Cognitive Acceleration in his meta-analysis and average effect size of these studies was 0.61. Main pillars or components of Cognitive Acceleration are derived from the ideas of Piaget and Vygotsky and are described in the following section.

**Pillars of Cognitive Acceleration**

There are five main pillars of Cognitive Acceleration namely *concrete preparation, cognitive conflict, social construction, Meta cognition* and *bridging* (Adey, Shyer, & Yates, 2001; Adey, Robertson, & Venville, 2001; Adey et al., 2002; Yates, 2006). Shayer and Adey (2002), however, mentioned *schema theory* and Adey and Shyer (1994) discussed *density* and *duration* as an additional pillar of Cognitive Acceleration. This gives rise to seven principles of Cognitive Acceleration in all, which are narrated here.

**Schema theory.** Piaget’s theory implies that experiences and intervention provided to the child should correspond to his developmental stage (Wilson, 2000). Description of distinct schemata at distinct ages provides a clear set of types of thinking in which intervention can be offered effectively. CASE targets the schemata of formal operational stage whereas CASE @KS1 focuses on the schemata of concrete operational stage (Shayer & Adey, 2002).

**Density and duration.** Cognitive Acceleration contemplates development of
thinking as a part of overall development. Development depends on maturation as well as on environmental influences. Same is true for development of thinking. Cognitive acceleration believes on the central processing ability of mind and focuses on its development. The notion of development implies that stimulating environment affects the development of thinking slowly and it should be sustained for a substantial period of time. Density implies the concentration with which students are exposed to stimulating experience. Both density and duration are important for permanent effect on the development of thinking of students (Adey & Shyer, 1994).

**Concrete preparation.** This is the first stage of Cognitive Acceleration intervention. At this stage, students are familiarized with the material and the situation. It is ensured that students know all vocabulary that is required for the lesson that is to be given to them on the day.

**Cognitive conflict (cognitive challenge).** Cognitive conflict involves introducing the children with the challenging experiences that are puzzling to them and cannot be easily explained with the existing schema of children. Development of more powerful schema is only possible when cognitively challenging experience is introduced and properly handled. Cognitive challenge is necessary for intellectual development (The Open University, n.d.).

**Social construction.** Need to effectively deal with the challenging task gives rise to the climate for the next pillar, social construction. Social construction is the constructing of knowledge with the help and collaboration of peers by listening to each other and discussing and solving the problem together under the guidance of teacher.

**Meta cognition.** Cognitive development is aided if children are consciously aware of their own thinking. Meta cognition component provides an experience of thinking out aloud and self-evaluation of own learning. Reflecting on critical incidents
and on turning points in our thinking can be a valuable tool for development of thinking (The Open University, n.d.). According to Matlin (2003), meta cognitive knowledge helps us in selecting appropriate strategies for improved future performance. Meta cognition gives self-awareness to the children and helps them to be self-evaluative (Fisher, 2007). Reflecting on the problem-solving process leads the children to gain Meta cognitive knowledge which in turn leads towards their improved performance on future tasks (Meyer et al., 2008).

**Bridging.** Bridging is the linking up of current learning with the previous learning. Linking may be either with the concepts of curriculum or with the experiences of daily life.

According to Adey and Shayer (1994), schema theory and cognitive conflict have emerged from Piagetian theory; Meta cognition and bridging have their origin in the ideas of Vygotsky and Feuerstein whereas concrete preparation and construction are supported by Piaget as well as by Vygotsky and Feuerstein.

**Cognitive Acceleration Studies**

The first Cognitive Acceleration study was Cognitive Acceleration through Science Education (CASE) and was conducted during 1980s. CASE intervention lessons were designed based on the schema of formal operational stage as described by Inhelder and Piaget (1958). The study was conducted on 10 experimental classes, 4 of which comprised 11+ students studying in year 7 whereas other 6 classes comprised 12+ students studying in year 8. The study aimed at development of formal operational thinking through the lessons developed in the context of science. Results showed that students of experimental group were better than those in the control group not only on delayed Piagetian Reasoning Tasks (PRT) but also on the General Certificate of Secondary Education (GCSE) exam that was conducted two (for 12+ group) and three (for 11+ group)
group) years after the intervention period. CASE program accelerated the thinking not only in Science, but also in Mathematics and English over time thus providing evidence for long term far transfer (Adey & Shayer, 1994).

Following the successful results of CASE project, cognitive acceleration tried out in the other subject areas and at other levels. Cognitive Acceleration programs developed in the subjects of Math and Science for Primary grades, Math and Technology for Secondary classes, and Music, Drama and Visual Arts for lower secondary classes (Yates, 2006). Cognitive Acceleration in Mathematics Education (CAME) (for year 7-8, age 12-14), Cognitive Acceleration in Mathematics Education (CAME) primary (for year 5-6), Cognitive Acceleration in Mathematics Education at key stage 1 (CAME@KS1) (for year 1-2), Cognitive Acceleration in Technology Education (CATE) (for year 7-9 and for year 10-11), Wigan Arts, Reasoning And Thinking Skills (Wigan ARTS) (for year 7-8), Cognitive Acceleration through Science Education at key stage 1 (CASE@KS1) (for year 1, age 5-6), and Cognitive Acceleration through Science Education at key stage 2 (CASE@KS2) (for year 3, age 7-8) are the cognitive acceleration programs that have been developed and implemented (Shayer & Adey, 2002).

It is assumed that if some time is devoted to intervention besides instruction in the early years of life, it pays off more and the instruction to these children would be more effective in the later years (Adey & Shayer, 1994). Duration concerns are very important for an intervention programs that focus on the development rather than learning. According to Feuerstein et al. (1980), successful cognitive intervention requires at least two years to leave an enduring effect on the development of thinking skills. However, it was hypothesized that for young children, intervention might affect the development of thinking in shorter period of 1 year as 1 year is 20 % of 5 year child’s life span. The
hypothesis proved to be true and the thinking skills of children of age 5 were developed successfully through the intervention provided over a period of one year (Shyer & Adey, 2002).

Cognitive Acceleration through Science Education at Key Stage 1 (CASE@KS1) was developed to accelerate the development of concrete operational thinking in the children of age 5+. CASE@KS1 activities were based on the schema of concrete operational level. The program was implemented in the disadvantaged areas of London. There were 10 experimental schools having 14 year 1 classes and 5 control schools having 8 year 1 classes in this study. Three listening and 26 Cognitive Acceleration activities were conducted through one year. A significant effect was observed on the cognitive development of children of experimental group (Shayer & Adey, 2002). Cattle and Howie (2008) replicated CASE@KS1 study in a rural area of UK using small sample (N=22).

According to Higgins and Hall (2004), the effect of thinking skills interventions on the students is age and context specific. Following section examines the effect of Cognitive Acceleration on the children of different age and gender.

**Effect of Cognitive Acceleration on Age and Gender**

The results of CASE project showed that effect of intervention was not same for boys and girls of different age groups. CASE intervention significantly affected the performance of 11+ girls and 12+ boys on delayed Piagetian Reasoning Tasks (PRT) as well as on achievement in GCSE Science, Mathematics and English. On the other hand, in 11+ boys and 12+ girls, significant difference was not observed between the experimental and control groups. Effect of CASE intervention on age and gender was explored in further studies as well. Parkside study revealed that effect of CASE intervention is more on the girls than on the boys. Korean study implemented the CASE
intervention at grade 5 (10.25 year mean age at the start) and at grade 6 (11.25 year mean age at the start). It was revealed that in age group 10+, the effect of intervention was higher on the boys compared to girls. From all these three studies, Adey and Shayer (1994) concluded that age 11+ might be critical for girls where intervention was more beneficial for them.

Shayer and William (1984) analyzed CSMS data to explore cognitive development spurts as suggested by Epstein (1980), if there were any. They identified that brain spurts and patterns of data can be interpreted in terms of Piagetian stages; brain spurt at 5-6 year age that leads to prepare for concrete operational level and brain spurt at 10-11 years age that leads to prepare for formal operational level. Brain spurts seemed to occur at the age of 11 and 14. At the age 11+, magnitude of spurt was found three times greater for girls, whereas in the latter case, it was greater for boys. Brain growth spurts might be a good explanation for the higher effect of intervention for girls at 11+ and for boys at 12+ age. It was deduced that spurts for formal operational level appear later in the boys as compared to girls (Adey & Shayer, 1994).

Epstein (1999 a) described the phases of rapid brain growth as 3-10 months and 2-4, 6-8, 10-12 and 14-16 years during which intervention proves to be more effective. According to Epstein (n. d.), gender differences exist in the phases of brain spurts of 2-4, 6-8, 10-12 and 14-16 years. He discussed in detail the brain spurt phases of 10-12 and 14-16 year and reported that they were striking. According to him, during the phase 10-12 year, girls have more symmetrical brain growth and their brain growth is twice as compared to boys, whereas boys have relatively less brain growth during this phase. In the phase 14-16 year age, situation reverses and the boys have symmetrical and at least twice brain growth as compared to girls whereas girls have relatively less brain growth in this phase. Gender differences in 2-4 and 6-8 year phases, however, were not reported.
Comparative effect of intervention for accelerating the formal operational level of children of different age and gender has been examined through several studies. However, such comparative effects of Cognitive Acceleration are not reported for the development of concrete operational level. Both of the CASE @KS1 studies were conducted in UK, where the age-range of children in class one is 5-6 years. In Pakistan, however, students of grade 1 belong to heterogeneous age groups ranging from age 5+ to 8+. Higgins et al. (2005) emphasizes on the need to explore the areas where the effects of intervention may be more prominent, such as different age groups. The current study explores the effect of Cognitive Acceleration (CASE @KS1) on the thinking skills of children of different age and gender. Study examines the age group of boys and girls in which intervention for accelerating the concrete operational level is more beneficial in relation to brain spurts as described by Epstein (1999a).

Developing Thinking Skill of Early School Children

It has been recognized since a long period of time that early years of life are decisive and influential for a person. Since very ancient time, theoretical and practical interests in early childhood are there and a wide range of basic and applied disciplines like Biology, Psychology, Sociology, Anthropology, Economics, Education, Social Policy, Health Research, Law and Development Studies have been contributing towards this important phase of life (Woodhead, 2006). Plato (428-348BC) identified the importance of this phase and expressed that first step is always the most important. During early years, children are taking shape and any effort of ours for them leaves an enduring impression on them (Clarke & Clarke, 2000).

Early childhood, the period from conception to the age 8 (up to grade 2) is crucial in terms of overall development of a child including the development of cognition and thinking (Agha Khan Foundation & Royal Netherlands Embassy, n.d.). Children acquire
concepts, skills and attitudes at this stage (Ministry of Education, 2003). Child
development studies revealed that enormous development occurs in the thinking capacity
during the early years of life. There is growth in brain size as well as development in
thinking. Most of the growth in human brain occurs during early childhood level. Brain
size is about 90% of the adult size by the age of 6. Intervention might be more effective
when brain is still growing, as compared to when brain is fully developed (Wilson, 2000).
Young brain is like super sponge absorbing every experience into its neural architecture.
Experiences are like food for brain. Appropriate environment challenges the children to
think in new ways. The way of learning in children in their early years makes a
significant difference in their lifelong learning and development (Australian Chamber of
Commerce and Industry, 2007). It is utmost important to thoroughly understand the
importance of this period and to offer a good start in life by providing stimulating
environment to them (Agha Khan Foundation & Royal Netherlands Embassy, n. d.). It is
the stage where if we give attention to the development of thinking, it would pay off
more. However, fewer thinking skills development programs are developed at primary
level. In Higgins et al.’s (2005) meta-analysis, 9 out of 29 studied were conducted at
primary level whereas 20 studies were conducted at secondary level.

Early school years are the bedrock and foundation stone of educational pyramid.
Focusing the development of children has deep, direct and determining effect on the
overall development of the country. Investment at this level contributes towards the well
being of youngsters and strengthens the economy of the nation and at large of the world
(Wordpress, 2007). However, the qualitative improvement of education is the pre-
requisite for social and economic benefits of education. National Plan of Action for
Education For All 2001-2015 (Ministry of Education, 2003 b) recognizes the importance
of quality of education in early school years with the intention that our generation can
gain competitive edge to meet the needs of knowledge based global economy. The Plan sets as one of its goal to improve all aspects of quality of education especially the literacy, numeracy and essential life skills. The Plan suggests four measures for this purpose, namely improving the standards of teachers, improving curriculum, improving assessment practices and revamping of science education. The Plan emphasizes on the project oriented and activity based curricula especially at early childhood level that would encourage enquiry, creativity and thinking. National Education Policy 1998-2010 also highlights on the need of modifying the curriculum to create a relationship between education and environment (Ministry of Education, 2003 a).

It is necessary to give the students something interesting to think about in order to make the thinking skills intervention program effective (Kizlik, 2009). In other words, the content of thinking should be interesting for children. According to Al-Fadhli and Khalfan (2008), there is a growing conviction among the researchers that thinking can be better promoted in a learner centred constructivist environment, where learner is actively involved in learning experience. According to Nisbet (1990), thinking demands effort and active involvement on the part of learner. Activities were used in the study in order to actively engage the young children in thinking and to maintain their motivation. It is easy to catch the attention of young children towards the thinking endeavor through the use of activities.

An attractive, activity based, conducive and interactive environment is necessary for the development of thinking skills of young children where active participation of children and social construction is ensured. Science activities based on Cognitive Acceleration were used in the current study for the development of thinking skills. They incorporate the main pillars of Cognitive Acceleration. Cognitive conflict was inbuilt in the activities. Activities were conducted in small groups in order to maximize the social
construction. Activities have been developed in the context of science.

Following section addresses science and its relation with thinking skills.

**Developing Thinking Skills through Science**

Thinking skills can be developed through various subjects. However, intervention provided in the subject of science was found to be more effective, the reason of which according to Higgins et al. (2005) is that thinking skills are the major focus of the science itself.

This is the era of science and technology. Man has discovered knowledge and invented things. The modern advancement is not mainly the result of the knowledge revolution, but the revolution in thinking (Brothers, 1999). Science is a way of knowing. It is an ongoing process that focuses on the developing and organizing knowledge. Science is both a process and product. The nature of science can be represented by a dynamic relationship among three factors, body of scientific knowledge, values of science and scientific methods and processes. Scientific knowledge is the product of science (Trowbridge & Bybee, 1990). Traditional science classrooms emphasize mostly on the scientific knowledge. However, an increasing need is being felt among the science community to introduce the learners about the process of discovering the knowledge of science (Yang, 2004). The use of scientific thinking in all areas of life is necessary for a society to be powerful (“Scientific”, 2000). Science education helps in the developing thinking skills and critical attitude and this is what makes the justification of introducing it among the students (Byrne & Johnstone, 1987).

Science education particularly in early years of schools is not teaching scientific facts and discoveries. Rather it is a simultaneous three-way interaction between children, environment and the teacher. Children at this level can’t deal with abstract ideas. Rather they interact with concrete materials, features and events of their environment. This
environment may be their natural environment or may be intentionally created organized and enriched classroom, where children can express their spontaneous responses. In classroom environment this process is guided and even can be evoked by the teacher. Teacher enriches the environment and enhances the learning interaction of the children (Elstgeest, 1990).

Thinking skills interventions have been provided in different areas of curriculum: Science, mathematics and in various dimensions of literacy like reading comprehension. However, it was found that the average effect size of thinking skill intervention programs varies depending upon the area of curriculum in which intervention was being provided. In the meta-analysis study, five thinking skills intervention programs conducted in the area of science were included. An average effect size of 0.89 was found when the intervention was provided in the area of mathematics, 0.78 when the intervention was provided in the area of science and 0.48 when the intervention was provided in the area of reading. According to Higgins et al. (2005), greater effect of intervention in the subjects of mathematics and science might be due to the reason that thinking skills and the content that are taught in thinking skills intervention programs are also focused by these subjects.

**Thinking Skills and the Early School Education System in Pakistan**

There are three levels of Pakistani Educational system: Elementary, Secondary and Higher Education. Elementary Education comprises 1-8 years of schooling, secondary deals with 9-12 years of education and Higher Education is the 13th year of education to onwards. Elementary education is further subdivided into two levels; primary that lasts from 1-5 years of schooling and middle that lasts from 6-8 years of schooling. According to Ministry of Education (2009), gross enrolment ratio at primary level was 90 % and net enrolment ratio was 70 % during the year 2007-2008. Hence the
dropout rate for the said year was 22.22%.

Traditional school system in Pakistan comprises Public schools managed by the Government. However, Private schools are emerging in Pakistan. These self owned Private schools are increasing at a notable speed and are becoming an important component of Pakistani school system (Andrabi, Das, & Khwaja, 2002). According to Andrabi, Das, and Khwaja (2006), private schools cater about 35% of children in Pakistan at primary level. However, according to Pakistan Education Statistics 2006-07, 31.2% children at primary level were enrolled in private sector whereas 68.8% were enrolled in the public sector (Ministry of Education, 2008).

Public and private sector differ from each other on a number of dimensions. Public sector programs are characterized by the scarcity of resources, corruption and lack of accountability. Private sector shows concerns for customers, claims for quality and charge high fee. They also provide variety in their curriculum (Myers, 2002). According to Çepni, Özsevgeç, and Cerrah (2004), private schools cater students of high socio-economic status that pay high fee. They maintain optimal class size, good quality of instruction, and better physical facilities to the students. In Pakistan, however, it is not necessary that private schools cater only rich students and offer luxurious environment and opportunities (Human Development Foundation, 2002). All over the world, private schools provide education to the privileged students and the contribution of private schools at higher levels is greater as compared to primary level. In Pakistan, the case is reverse. Here, the contribution of private schools is greater at primary level compared to secondary level and a considerable number of these schools cater poor students (Das, Andrabi, & Khwaja, n.d.).

There is a variety of private schools in Pakistan in terms of fee they charge and facilities and quality they offer. Usually, parents infer about the quality of private schools
from their fee. Mainly, there are two kinds of private schools; high quality private schools that can be approached only by elite class and inexpensive schools that are affordable for middle and even low income people. The private schools of the latter category cater a wide range of population (Andrabi et al., 2002). According to Andrabi et al. (2006), these private schools provide comparable facilities with public schools by spending half expenditure compared to public schools (1012 versus 2039 Rupees per child per year). They do this because they hire female teachers and pay them only 20 % of the salary of that of the public school teachers. Educational qualification of public and private school teachers is comparable. Teachers in public schools have additional professional qualification whereas teachers of private schools are untrained and less experienced (Andrabi et al., 2002). Student teacher ratio is 37 in public sector (Ministry of Education, 2008) and 24.8 in private sector. In this way, more time per student is spent in private sector (Andrabi et al., 2002). Entry age in grade 1 is 5 years old. However, due to low net enrolment, admission is offered to elder children as well, especially private schools easily cater these children. Mean age of children of grade 1 was found to be 6 years and 11 months at the time of pretest.

Thinking skills programs have been conducted in several countries of the world and nearly half of these thinking skills development programs were conducted in UK and US. However, no substantial work has been done in Pakistan for the development of thinking skills. Higgins et al. (2005) reported only one such study that was conducted in Pakistan. Current study explores the effect of Cognitive Acceleration intervention at early school children of Pakistan and explores the factors that contribute towards the development of thinking skills at this level.
CHAPTER III

Method and Procedure

This chapter describes the design of the study, sample, instrument, treatment, material used, time frame, data analysis and procedure of the study.

Experimental Design

Quasi-experimental design was used in the study with the pre and posttest. Intact groups were used so that some children within the class do not feel themselves being deprived from the treatment that was in the form of activities. However treatment was randomly assigned to one of the two intact groups of a school. Design of the study is represented in the Figure 3.1.

![Figure 3.1. Design of the study.](image)

Sample of the Study

Students of class one were the population of the study. Schools were selected conveniently, where administration of the school were accommodative to conduct the experimental study. A total of 273 students were included in the sample, out of which 126 were boys and 157 were girls. Total number of children present at the time of pre and
posttest are given in Table 3.1

Table 3.1

*Total Number of Children at the Time of Pre and Posttest*

<table>
<thead>
<tr>
<th></th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>126</td>
<td>147</td>
<td>273</td>
</tr>
<tr>
<td>Posttest</td>
<td>108</td>
<td>123</td>
<td>231</td>
</tr>
</tbody>
</table>

During the study, 42 subjects were dropped from the schools and hence from the study. Dropout rate among the subjects of the study was 15.38 %, which is less than the national dropout rate at primary level (22.22 %) during the year 2007-8 (Ministry of Education, 2009). The children who were dropped from the schools during the study were excluded from data analysis. Data of only those children were analyzed which were present both at the time of pretest and posttest.

Four experimental and five control classes selected from two public and four private schools were included in the study. Private schools were included in the study because of their increasing share in Pakistani school system. Those private schools participated in the study, which represent the large segment of private schools and that are affordable for middle and poor class. Experimental and control groups of different schools are presented in Table 3.2. Table also shows total number of children and gender wise distribution of children at each school at the time of posttest.

Table 3.2

*Experimental and Control Groups of Different Schools*

<table>
<thead>
<tr>
<th>Schools</th>
<th>Sector</th>
<th>Experimental group</th>
<th>Control group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Boys</td>
<td>Girls</td>
<td>Boys</td>
</tr>
<tr>
<td>School 1</td>
<td>Public</td>
<td>9</td>
<td>20</td>
<td>13</td>
</tr>
<tr>
<td>School 2</td>
<td>Public</td>
<td>13</td>
<td>19</td>
<td>24</td>
</tr>
<tr>
<td>School 3</td>
<td>Private</td>
<td>16</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>School 4</td>
<td>Private</td>
<td>7</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>School 5</td>
<td>Private</td>
<td>-</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td>School 6</td>
<td>Private</td>
<td>-</td>
<td>-</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td><strong>45</strong></td>
<td><strong>56</strong></td>
<td><strong>63</strong></td>
</tr>
</tbody>
</table>
Schools selected in the study were different regarding syllabi they teach to the children. In school 3 and school 5, Oxford syllabus was being taught, whereas in rest of the two private and both public schools, National syllabus was being taught.

Ages of the children at the time of pretest were ranging from 62 to 125 months \((M = 83, SD = 11.4)\). Ages of children were calculated by using their date of births record maintained by the schools. The age groups in which experimental and control group children were at the time of pretest are mentioned in Table 3.3. Comparative effect of science activities on the development of thinking skills of children, and of boys and girls of 5+, 6+, 7+ and 8+ age groups is analyzed separately in chapter 4.

Table 3.3

*Age Wise Distribution of the Sample*

<table>
<thead>
<tr>
<th>Age</th>
<th>Experimental group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boys</td>
<td>Girls</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Data not available</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>45</td>
<td>56</td>
</tr>
</tbody>
</table>

**Instruments of the Study**

Early school children may be either at preoperational or at concrete operational level. Concrete operational stage is characterized by schema of operational thinking like conservation, reversibility and classification whereas preoperational stage lacks these. Those instruments were used in the study as pre and posttest that can measure the cognitive level of children from pre-operational to concrete operational level.

Two instruments were used in the study as pretest and posttest to measure the changes in cognitive development of early school children during the period of
intervention namely drawing test and conservation test. They are described below:

**Drawing test.** This test was used to measure the spatial perception of the children. Group version of Drawing Test was used in the study. It was developed by Shayer et al. (1978) and is based on original Piagetian protocols (Piaget & Inhelder, 1976). It is developed for the children ranging from pre-conceptual to late concrete operational level (0----2B). Scores on this task enable the researcher to place the children on the scale of cognitive development ranging from pre-conceptual through late concrete operational level (Wylam & Shayer, 1978). This test was administered in groups of six according to the instructions of the test so that it can be ensured that children are following the guidelines properly and are attempting at right place on their answer sheet.

Drawing test comprised the water level and plumb line tasks. An answer sheet was provided to the children. This answer sheet is attached in appendix. Answer sheet contains A to L pictures of bottles and jars in different positions. Children were required to show water level or plumb line in these pictures in different situations.

For water level tasks, two 250 ml bottles with stoppers were used. One bottle was partially filled with water. A to G items were related to water level tasks. In item A, bottle with one third water was shown to the children and they were asked to draw the level of water with shading in the picture A. Next, for item B, the empty bottle was put on side and children were asked to imagine and draw the water level if the water bottle were laid in this way. When children did item B, water bottle laid in its side position was shown to the children. When all children saw this, it was put in upright position and children were asked to draw water in picture C as they just have seen. This practice was repeated by inverting the bottle (D-E) and tilting the bottle (F-G). Each time, children were provided two opportunities to draw, first time before actually seeing the water level and second time after seeing it.
For plumb line tasks, two jam jars were used with their lids. In one jar, a plasticine ball hanging on a string was coming from the center of the lid. The same procedure was used that was used in water level tasks. Jar in upright position was shown in H, with tilted position in items I-J and with side position in items K-L and it was asked to draw plumb line. In each pair of items, children were asked firstly to predict the plumb line by looking at empty jar, whereas in second instance they were asked to record the plumb line as they have just seen.

Except for A and H, all items were scored in pairs. Marking was done keeping in view their correctness both in prediction and recording. Item H was not scored. Maximum marks were 4 for items B-C, D-E, I-J and K-L; 1 for item A and 5 for items F-G, thus giving total maximum marks of 22 on drawing test. Table 3.4 presents the key for estimating the cognitive level of children from the raw scores on drawing test.

Table 3.4

<table>
<thead>
<tr>
<th>Raw scores</th>
<th>Piagetian level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>pre conceptual</td>
<td>0</td>
</tr>
<tr>
<td>4-9</td>
<td>early preoperational</td>
<td>1A</td>
</tr>
<tr>
<td>10-13</td>
<td>late preoperational</td>
<td>1B</td>
</tr>
<tr>
<td>14-18</td>
<td>early concrete</td>
<td>2A</td>
</tr>
<tr>
<td>19-21</td>
<td>mid concrete</td>
<td>2A/B</td>
</tr>
<tr>
<td>22</td>
<td>mature concrete</td>
<td>2B</td>
</tr>
</tbody>
</table>

**Conservation test.** Conservation test included Piagetian conservation of number, liquid amount, solid amount and weight. These tests of conservation measure the cognitive development of children from late pre operational to mid concrete operational level (1B – 2A/2B). There were total eight tasks in conservation test, two were related to conservation of number, one related to conservation of liquid amount, three related to conservation of solid amount and two related to conservation of weight. Description of these tasks is given below:
**Conservation of number.** For conservation of number, two tasks were administered. Both of these tasks measure late pre operational level (Piagetian 1B) of cognitive development. The tasks were as follows:

1. Six cups were and six small balls were used for the first task. The cups were placed with a distance of 10 cm among them and one ball was put in each of the cup. It was ensured that the child believes that there are as much balls as are the cups. Now the balls were taken out of cups and placed closed together with a distance of 5 cm, whereas the cups were spread apart from each other with a distance of 15 cm among them. The child was asked if the balls were in the same number as are the cups. If the child replies ‘yes’, she is asked to give the reason. The explanation like ‘nothing is added or taken out’ was considered a good one. Counting was not considered good explanation.

2. The second task of conservation of number was administered by using about twenty artificial roses in red and yellow colors. Child was asked to choose the color she likes. One by one, flowers of each color were placed opposite to each other by the researcher and the child, until both the researcher and the child had one row containing six flowers. It was ensured that the child believes that both rows contain equal flowers. Now, one of the rows was bunched from 10 cm to 5 cm and other was spread from 10 cm to 15 cm. Questions regarding the conservation of number and the reason were asked and analyzed in the same way as in task 1.

**Conservation of liquid amount.** One task was used to ascertain the conservation of liquid amount. This task measures the early concrete operational level (2A) of cognitive development.

Conservation of liquid amount was measured by using (A) one 250 ml beaker
(around 8 cm diameter and 10 cm high) (B) one 250 ml cylinder (around 3.5 cm diameter and 32 cm high) and (C) a small beaker with 50 ml (around 4.5 cm diameter and 6 cm high). C was used to pour water into beaker and cylinder. Each time C was filled up to the same mark and child’s attention was focused towards this. C filled to the mark was poured three times to A and three times to B. Questions were asked regarding conservation and counter questioning was made to explore the justification of child regarding the amount of water in containers A and B.

**Conservation of solid amount.** Tasks of conservation of solid amount measure the early concrete operational level (2A) of cognitive development. Three such tasks were used which are as follows:

1. Two plasticine balls of 5 cm were made. It was ensured that child believes them containing the same amount. One ball was converted into 15 cm long sausage. Questioning was made regarding the conservation and counter questioning was made to explore the explanation of child regarding the amount of plasticine. Explanations like ‘nothing is taken out or added into it’ or ‘this is longer but thinner’ were considered as good justifications.

2. Sausage was converted again into ball. Equivalence was re-established. Child was given the opportunity to equalize the balls if she believed that either of the ball has more amount of plasticine. One of the balls was flattened to make a pancake or ‘Roti’. Child was asked if ball and pancake have equal amount of plasticine or either contained more amount. Child’s reasoning was explored for the answer he has given.

3. Pancake was transformed back into ball and equivalence between the two balls was re-established. One of the balls was converted into five little balls. Questions were asked about the amount of material in one bigger ball and in five little balls.
Reason was explored for the answer child has regarding the amount.

*Conservation of weight.* Two tasks were used to determine the conservation of weight. Both of these tasks measure mid concrete operational level (2A/B) of cognitive development. The tasks were as follows:

1. Two equal balls of plasticine were taken as were used in the tasks of conservation of solid amount. Each ball was placed on each sides of the balance. It was ensured that the child was agreeing with the equality of weight of the two balls. One ball was converted into pancake and questions were asked regarding the conservation of weight. Justification was required for the answer.

2. One ball of plasticine was placed one on each side of the balance. After establishing the equality of balls, one ball was converted into five little balls. Questions were asked regarding the conservation of weight.

In each the above mentioned eight tasks, one mark was given for conservation plus good explanation. Maximum marks on this test were 8. No mark was assigned for conservation without its justification.

Conservation test was conducted individually. This test was conducted on one third stratified sample. On the base of drawing test scores, three strata were formed: High, mid and low scorers. From each stratum, one third children were selected for conservation test. Children of both genders were selected proportionately in the sample.

**Science Activities Used as Intervention**

A total of 30 science activities (*Let’s think*) were used as treatment. These activities have been developed in the context of science by Adey et al. (2001). Each activity was conducted with the interval of one week. The treatment period was thirty working weeks or one academic year. Activities were conducted in the group of six or seven children so that social construction can be maximized. Activities were conducted
mixed ability groups. On average, for one group, each activity has taken the time of about 30 minutes. All the activities incorporated the basic features of cognitive acceleration. Material of the activities was developed by the researcher in the light of teacher’s guide of ‘Let’s Think!’ activities.

Among 30 activities, 3 were listening and 27 were main activities. The purpose of Listening activities (Activity A: Clown faces; Activity B: Space; and Activity C: Animals) was to familiarize the children with cognitive intervention methodology and to introduce them how they should listen each other with respect and how they should express their viewpoint or disagreement before other children. The main activities are based on the schema that children form during concrete operational stage. The schemata that were addressed in the intervention program are as follows:

**Seriation.** Seriation is putting the things in ascending or descending order on the basis of some feature like length, width, weight or size. Six activities (Activity 1: Sticks; Activity 2: Flowers; Activity 3: Marble Run; Activity 10: Stones; Activity 11: Boxes; Activity 15: Library books) were related to the schema of seriation. According to Adey et al. (2002), it is very difficult for children at pre operational level to focus their attention to more than two things at a time. In these activities, however, 9 to 20 objects were provided to the children so that they arrange them according to one or more characteristics. Focusing the attention on more than two objects at a time places a demand on the working memory of the children.

**Classification.** Classification is to categorize the objects into groups on the basis of some variables like color, shape or size. Each variable may have several values. For example, variable color has the values red, blue and green. A total of eight activities (Activity 4: Sorting shapes; Activity 5: Farm animals I; Activity 6: Buttons; Activity 7:
Farm animals II; Activity 9: Cars; Activity 13: Living? Activity 14: Guess what?

Activity 19: Bricks) were related to the classification schema. In these activities, children were required to classify objects with several variables and several values of each variable. Children were challenged to solve the problem if some object has the characteristics of two classes. They were encouraged to think about various variables on the basis of which the objects can be classified.

**Time sequence.** According to Adey et al. (2001), *time sequence* is a category of *seriation* schema. In the place of objects, children have to arrange events in a meaningful way. Children were provided with five to eight pictures in an activity and were required to arrange the pictures to create a logical story. Again, focusing attention on more than two pictures at a time places a demand on working memory of the children. There were four activities (Activity 8, Activity 12, Activity 21 and Activity 27) related to the schema of time sequence. Content of the activities regarding *time sequence* was changed according to the local context. Instead of ‘Lost Boot’, ‘Cooking’, ‘The Cat and Snail Story’ and ‘The Ice Cream Story’; pictures regarding following stories were provided to the children: *Cat and Rat, Routine of the day, Lion and Rat, and Girl and Wolf.*

**Spatial perception.** *Spatial perception* is the ability to perceive that what would be the view of a scene from different angles. Four activities (Activity 16: Crossroads I; Activity 17: Looking at shapes; Activity 18: Crossroads II; and Activity 26: Farmyard) were related to the schema of spatial perception. In all these activities, children see a scene from one position and they have to imagine and reflect about the scene from other positions. Focusing attention on the scene from the one's own position and from the others positions at the same time places demand on the working memory of the children.

**Causality.** This schema is related to cause and effect relationship. Three activities
(Activity 20: Rolling Bottles; Activity 22: Shadows; and Activity 25: Transformations) were related to this schema. In these activities, children were encouraged to explore the causes of some event and to predict the effect of some cause.

**Rules of games.** It is actually not a schema but a convenient label given by Adey et al. (2001) to two schemata, *theory of mind* and *concrete modeling*. Two activities (Activity 23: In this Town; and Activity 24: Making a game) were related to *Rules of games*. The first activity was related to *concrete modeling* which required the children to comprehend the relationship among several variables, the understanding of which became easy because of the *concreteness* of the variables. Second activity was related to schema *theory of mind*, which implies that it is important to appreciate the thought of others. Rules of a game were not fixed and arbitrary, but can be changed and can be devised by the agreement with the fellows.

The important thing in the activities was that they didn’t require one *correct* answer. Emphasis was on the exploring and searching alternative ways.

**Administration of Activities**

In school 4, activities were conducted by the researcher. In schools 1, 2 and 3, almost half activities were conducted by the researcher and half by the teachers. Teachers were trained for this purpose. Training comprised the following components:

1. Introduction about the cognitive acceleration methodology
2. Simulation of the activity
3. Provision of written guideline
4. Weekly discussion about the activity
5. Observation of the teacher to provide her feedback.

**Data Analysis**

Following statistics were applied to analyze the data.
**Mean scores and standard deviation.** Mean scores and standard deviation of experimental and control groups on drawing and conservation pretest, posttest, and gain scores were computed. Mean gain scores on drawing and conservation tests were calculated by subtracting pretest scores from posttest scores. Graphical presentation of gain scores of experimental and control groups on drawing and conservation tests was also given.

**Independent sample t-test.** Independent sample t-test was applied to compare the mean test scores of experimental and control groups. Independent sample t-test is a parametric statistical test used to compare the mean scores of two different and independent groups (Frankel & Wallen, 2003). Mean difference between the experimental and control groups was considered significant if p value was less than the 0.05 level of significance (p < 0.05). Independent sample t-test was applied on mean pretest scores, on mean posttest scores, and on mean gain scores of experimental and control group children to explore whether the experimental and control groups were significantly different with respect to their pretest scores, posttest scores, and gain scores.

**Effect size.** Effect size was calculated to measure the magnitude of the effect of treatment. Effect size is the difference between the two means divided by standard deviation (Cohen, 1988). In other words, it is the standardized mean difference between the two groups. It is a way of quantifying the size of the difference in the means of the two groups (Coe, 2002, September). Standard deviation of either group can be used if the variation of the two groups is homogeneous. However, commonly the pooled standard deviation $\sigma_{pooled}$ is used (Rosnow & Rosenthal, 1996) to calculate the effect size. The pooled standard deviation is the root mean square of the squared standard deviations (Cohen, 1988). Effect size was calculated on mean gain scores of experimental and control groups.
Effect size = Me-Me/σ_{pooled}

An effect size is exactly equivalent to a 'Z-score' of a standard Normal distribution (Coe, 2002, September) and hence it informs what percentile experimental group has moved compared to control group as a result of treatment. Unlike the significance tests, it is independent of sample size. Hedges’ g method was used in the current study that uses the standard deviation of the sample in contrast to Glass’s delta method that uses the standard deviation of control group and Cohen’s d method that uses the standard deviation of population. It is an inferential measure, and corrects the sample biasness. This method of estimating the effect size was used by Higgins et al. (2005) in his meta-analysis of thinking skills program. Hedges’ g effect size was calculated by using the excel spreadsheet provided by Higgins.
CHAPTER IV

Analysis and Interpretation of Data

This chapter presents the data analysis of experimental and control groups on scores on drawing and conservation tests. Experimental and control groups were compared on pretest scores, on posttest scores, and on gain scores by using independent sample t-test. Effect size was applied on gain scores and reported with 95% confidence intervals.

The data were analyzed in the following ways:

1. Comparison of experimental and control groups on scores on drawing and conservation tests

2. School wise comparison of experimental and control groups on scores on drawing and conservation tests

3. Comparison of children of experimental and control groups of public and private sectors on scores on drawing and conservation tests

4. Gender wise comparison of experimental and control groups on scores on drawing and conservation tests

5. Comparison of children of experimental and control groups of different age groups (5+, 6+, 7+ and 8+ year) on scores on drawing and conservation tests

Comparison of Experimental and Control Groups

Effect of intervention on drawing and conservation tests of children is presented in Table 4.1.
Table 4.1 shows that scores of experimental and control groups on drawing test were not significantly different before intervention \((p = .14)\). After intervention, experimental group performed significantly better than the control group on drawing test \((p < .001)\). Gain scores of experimental group on drawing test were also significantly higher than those of the control group \((p < .001)\). Effect size on gain scores on drawing test with 95% confidence intervals was 0.92 \([0.65, 1.19]\). These findings answered the research question 1 and showed that science activities were significantly and highly effective for accelerating the development of the schema that was addressed in the intervention program.

Table 4.1 shows that pretest scores of experimental and control groups on conservation test were not significantly different \((p = .18)\). Posttest scores of experimental group on conservation test were significantly higher than those of the control group \((p < .001)\). Gain scores of experimental group on conservation test were also significantly higher than those of the control group \((p < .001)\). Effect size on gain scores.
scores on conservation test with 95 % confidence intervals was 1.22 [0.75, 1.70]. These findings pertaining to the research question 2 revealed that science activities were significantly and highly effective for accelerating the development of the schema other than those addressed in the intervention program.

Gain scores of experimental and control groups on drawing and conservation tests were shown in Fig 4.1.

![Figure 4.1. Gain scores of experimental and control groups on drawing and conservation tests.](image)

**School Wise Comparison**

A total of six schools were included in the study. In three schools, both experimental and control groups were present, whereas in the rest of the three schools, either experimental or control group was present. Description of the experimental and control groups of all the six schools is given in Table 3.2. Independent sample t-test was applied and effect size was calculated for the three schools in which both experimental and control groups were present. Descriptive statistics of the group are reported for the schools in which either experimental or control group was present.

Effect of intervention on drawing and conservation tests of children of school 1 is
presented in Table 4.2.

Table 4.2

Effect of Intervention in School 1

<table>
<thead>
<tr>
<th>Group</th>
<th>Drawing test</th>
<th>Conservation test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest</td>
<td>Posttest</td>
</tr>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>29</td>
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<td>M</td>
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<tr>
<td>SD</td>
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<td>Control</td>
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<tr>
<td>SD</td>
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<td>4.76</td>
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<tr>
<td>Me - Mc</td>
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<td>0.73</td>
</tr>
<tr>
<td>t</td>
<td>3.23</td>
<td>0.61</td>
</tr>
<tr>
<td>p</td>
<td>.003</td>
<td>.54</td>
</tr>
<tr>
<td>ES</td>
<td>1.06</td>
<td></td>
</tr>
<tr>
<td>95 % CI</td>
<td>[0.49, 1.63]</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.2 shows that in school 1, pretest scores of control group on drawing test were significantly better than those of the experimental group (p = .003). After intervention, scores of experimental group on drawing test were higher than those of the control group, but the mean difference was not significant (p = .54). However, gain scores of experimental group on drawing test were significantly higher than those of the control group (p < .001). Effect size on gain scores on drawing test with 95 % confidence intervals was 1.06 [0.49, 1.63].

Pretest scores of experimental and control groups on conservation test were not significantly different (p = .99). Posttest scores and gains scores of experimental group on conservation test, however, were significantly higher than those of the control group (p = .01 and p = .005 respectively). Effect size on gain scores on conservation test with 95 % confidence intervals was 1.43 [0.42, 2.44].

Effect of intervention on drawing and conservation tests of children of school 2 is
shown in Table 4.3.

Table 4.3

*Effect of Intervention in School 2*

<table>
<thead>
<tr>
<th>Group</th>
<th>Drawing test</th>
<th>Conservation test</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest</td>
<td>Posttest</td>
<td>Gain scores</td>
</tr>
<tr>
<td>Experimental</td>
<td>32</td>
<td>19.25</td>
<td>7.03</td>
</tr>
<tr>
<td></td>
<td>M 12.22</td>
<td>1.64</td>
<td>6.45</td>
</tr>
<tr>
<td></td>
<td>SD 4.86</td>
<td>2.84</td>
<td>4.82</td>
</tr>
<tr>
<td>Control</td>
<td>37</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M 11.57</td>
<td>0.85</td>
<td>3.23</td>
</tr>
<tr>
<td></td>
<td>SD 5.30</td>
<td>4.49</td>
<td>4.35</td>
</tr>
<tr>
<td>Me - Mc</td>
<td>0.65</td>
<td>3.90</td>
<td>3.25</td>
</tr>
<tr>
<td>t</td>
<td>0.53</td>
<td>4.37</td>
<td>2.96</td>
</tr>
<tr>
<td>p</td>
<td>.60</td>
<td>&lt;.001</td>
<td>.004</td>
</tr>
<tr>
<td>ES</td>
<td>0.71</td>
<td>1.08</td>
<td></td>
</tr>
<tr>
<td>95 % CI</td>
<td>[0.22, 1.19]</td>
<td>[0.22, 1.94]</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.3 shows that pretest scores of experimental and control groups of school 2 on drawing test were not significantly different (p = .60). Posttest scores and gain scores of experimental group on drawing test, however, were significantly higher than those of the control group (p < .001 and p = .004 respectively). Effect size on gain scores on drawing test with 95 % confidence intervals was 0.71 [0.22, 1.19].

Performance of experimental and control groups on conservation test was not significantly different before intervention (p = .34). After intervention, experimental group performed significantly better than the control group on conservation test (p = .003). Gain scores of experimental group on conservation test were also significantly higher than those of the control group (p = .01). Effect size on gain scores on conservation test with 95 % confidence intervals was 1.08 [0.22, 1.94].

Effect of intervention on drawing and conservation tests of children of school 3 is presented in Table 4.4.
Table 4.4

**Effect of Intervention in School 3**

<table>
<thead>
<tr>
<th>Group</th>
<th>Drawing test</th>
<th>Conservation test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest</td>
<td>Posttest</td>
</tr>
<tr>
<td>Experimental</td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>11.70</td>
</tr>
<tr>
<td>Control</td>
<td>17</td>
<td>11.97</td>
</tr>
</tbody>
</table>

Table 4.4 shows that pretest scores of experimental and control groups on drawing test were not significantly different in school 3 (p = .86). Posttest scores and gain scores of experimental group on drawing test were higher than those of the control group, but the mean differences were not significant in both cases (p = .06 and p = .12 respectively). Effect size on gain scores on drawing test with 95 % confidence intervals was 0.48 [-0.14, 1.09].

Before intervention, performance of experimental and control groups on conservation test was not significantly different (p = .94). After intervention, experimental group performed significantly better than the control group on conservation test (p = .006). Gain scores of experimental group on conservation test were also significantly higher than those of the control group (p = .004). Effect size on gain scores on conservation test with 95 % confidence intervals was 1.30 [0.21, 2.38].

In school 4, 5 and 6, either experimental or control group was present. Independent sample t-test was not applied and effect sizes were not calculated for the
experimental and control groups belonging to different schools. However, descriptive statistics of these groups are given in Table 4.5.

Table 4.5

Scores of Children of Schools 4, 5 and 6 on Drawing and Conservation Tests

<table>
<thead>
<tr>
<th>School</th>
<th>Group</th>
<th>Drawing test</th>
<th>Conservation test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pretest</td>
<td>Posttest</td>
</tr>
<tr>
<td>School 4</td>
<td>Exp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>13</td>
<td>14.85</td>
<td>21.31</td>
</tr>
<tr>
<td>M</td>
<td>5.24</td>
<td>1.38</td>
<td>4.75</td>
</tr>
<tr>
<td>SD</td>
<td>5.24</td>
<td>1.38</td>
<td>4.75</td>
</tr>
<tr>
<td>School 5</td>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>22</td>
<td>15.23</td>
<td>17.95</td>
</tr>
<tr>
<td>M</td>
<td>4.68</td>
<td>4.17</td>
<td>4.17</td>
</tr>
<tr>
<td>SD</td>
<td>4.68</td>
<td>4.17</td>
<td>4.17</td>
</tr>
<tr>
<td>School 6</td>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>29</td>
<td>11.03</td>
<td>13.03</td>
</tr>
<tr>
<td>M</td>
<td>4.03</td>
<td>5.22</td>
<td>3.65</td>
</tr>
<tr>
<td>SD</td>
<td>4.03</td>
<td>5.22</td>
<td>3.65</td>
</tr>
</tbody>
</table>

Gain scores of children of experimental and control groups of different schools on drawing and conservation tests are shown in Fig. 4.2.

Figure 4.2. Gain scores of children of experimental and control groups of different schools on drawing and conservation tests.
**Sector Wise Comparison**

Experimental and control groups from both public and private sector schools participated in the study. This section presents the effect of intervention on the drawing and the conservation tests in the children of public and private sector schools. Effect of intervention on the children of public and private sector schools was given in Table 4.6.

Table 4.6:

*Effect of Intervention on Drawing and Conservation Tests of Children of Public and Private Sector Schools*

<table>
<thead>
<tr>
<th>Sector</th>
<th>Group</th>
<th>Drawing test</th>
<th>Conservation test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pretest</td>
<td>Posttest</td>
</tr>
<tr>
<td>Public</td>
<td>Experimental</td>
<td>n 61</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M 10.43</td>
<td>17.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD 4.54</td>
<td>3.79</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>n 62</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M 11.98</td>
<td>15.29</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD 5.44</td>
<td>4.56</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Me - Mc</td>
<td>-1.56</td>
</tr>
<tr>
<td></td>
<td></td>
<td>t 1.72</td>
<td>3.15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p .09</td>
<td>.002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ES 0.87</td>
<td>1.17</td>
</tr>
<tr>
<td>Private</td>
<td>Experimental</td>
<td>n 40</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M 12.73</td>
<td>19.90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD 5.11</td>
<td>2.34</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>n 68</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M 12.63</td>
<td>15.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD 4.77</td>
<td>5.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Me - Mc</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>t 0.10</td>
<td>5.84</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p .92</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ES 0.97</td>
<td>1.21</td>
</tr>
</tbody>
</table>

Table 4.6 shows that in public sector schools, pretest scores of experimental and control groups on drawing test were not significantly different (p = .09). However,
posttest scores and gain scores of experimental group on drawing test were significantly higher than those of the control group ($p = .002$ and $p < .001$ respectively).

In private sector schools, scores of experimental and control groups on drawing test were not significantly different before intervention ($p = .92$). Posttest scores and gain scores of experimental group, however, were significantly higher than those of the control group ($p < .001$ in both cases).

Effect size on gain scores on drawing test with 95% confidence intervals was $0.87 [0.50, 1.24]$ in public sector schools and $0.97 [0.56, 1.38]$ in private sector schools.

Table 4.6 shows that in public sector schools, performance of experimental and control groups on conservation test was not significantly different before intervention ($p = .51$). Posttest scores and gain scores of experimental group on conservation test, however, were significantly higher than those of the control group ($p < .001$ in both cases).

Experimental and control groups of private sector schools were not significantly different on conservation test before intervention ($p = .15$). Posttest scores and gain scores of experimental group on conservation test were significantly higher than those of the control group ($p < .001$ and $p = .002$ respectively).

Effect size on gain scores on conservation test with 95% confidence intervals was $1.17 [0.52, 1.82]$ in public sector schools and $1.21 [0.52, 1.90]$ in private sector schools.

These findings pertaining to the research question 3 showed that the effect of intervention was significant and high for the development of thinking skills of children of both public and private sector schools. However, when the values of the effect sizes on gain scores on drawing and conservation tests of the children of public and private sector school were compared, a slight difference was observed that was in the favor of private sector schools. Thus, the intervention affected the cognitive development of children of
private sector schools a little more.

Gain scores of children of experimental and control groups of public and private sector schools on drawing and conservation tests are shown in Fig. 4.3.

Figure 4.3. Gain scores of children of experimental and control groups of public and private sector schools on drawing and conservation tests.

Gender Wise Comparison

This section presents the effect of intervention on the drawing and conservation tests of boys and girls.

Scores of boys and girls of experimental and control groups on the drawing and the conservation tests are given in Table 4.7.
Table 4.7

**Effect of Intervention on Drawing and Conservation Tests of Boys and Girls**

<table>
<thead>
<tr>
<th>Gender Group</th>
<th>Drawing test</th>
<th>Conservation test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest</td>
<td>Posttest</td>
</tr>
<tr>
<td>Boys Experimental</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>45</td>
<td>16</td>
</tr>
<tr>
<td>M</td>
<td>12.76</td>
<td>19.09</td>
</tr>
<tr>
<td>SD</td>
<td>4.80</td>
<td>3.34</td>
</tr>
<tr>
<td>Me - Mc</td>
<td>0.41</td>
<td>3.07</td>
</tr>
<tr>
<td>t</td>
<td>0.43</td>
<td>3.90</td>
</tr>
<tr>
<td>p</td>
<td>.67</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td>ES</td>
<td>0.62</td>
<td></td>
</tr>
<tr>
<td>95 % CI</td>
<td>[0.22, 1.01]</td>
<td></td>
</tr>
</tbody>
</table>

Control

|              |        |          |              |        |          |              |
| n            | 63   | 21       |              |        |          |              |
| M            | 12.34 | 16.02    | 3.67         | 1.14   | 2.43     | 1.29         |
| SD           | 5.06  | 4.85     | 4.40         | 1.88   | 2.29     | 1.49         |
| Me - Mc      | 0.41  | 3.07     | 2.66         | 1.67   | 3.95     | 2.28         |
| t            | 0.43  | 3.90     | 3.18         | 2.21   | 5.93     | 2.97         |
| p            | .67   | p < .001 | .002         | .03    | p < .001 | .007         |
| ES           | 0.62  |          |              |        |          |              |
| 95 % CI      | [0.22, 1.01] |          | [0.35, 1.73] |        |          |              |

Girls Experimental

|              |        |          |              |        |          |              |
| n            | 56   | 21       |              |        |          |              |
| M            | 10.20 | 18.13    | 7.93         | 0.95   | 5.29     | 4.33         |
| SD           | 4.69  | 3.53     | 4.76         | 1.77   | 2.67     | 2.37         |
| Me - Mc      | -2.10 | 3.05     | 5.15         | -0.13  | 2.79     | 2.92         |
| t            | 2.35  | 4.10     | 6.57         | 0.24   | 3.65     | 4.52         |
| p            | .02   | p < .001 | p < .001     | .82    | .001     | p < .001     |
| ES           | 1.18  |          |              |        |          |              |
| 95 % CI      | [0.80, 1.57] |          | [0.68, 1.97] |        |          |              |

Control

|              |        |          |              |        |          |              |
| n            | 67   | 24       |              |        |          |              |
| M            | 12.30 | 15.07    | 2.78         | 1.08   | 2.50     | 1.42         |
| SD           | 5.16  | 4.72     | 3.93         | 1.93   | 2.45     | 1.95         |
| Me - Mc      | -2.10 | 3.05     | 5.15         | -0.13  | 2.79     | 2.92         |
| t            | 2.35  | 4.10     | 6.57         | 0.24   | 3.65     | 4.52         |
| p            | .02   | p < .001 | p < .001     | .82    | .001     | p < .001     |
| ES           | 1.18  |          |              |        |          |              |
| 95 % CI      | [0.80, 1.57] |          | [0.68, 1.97] |        |          |              |

Table 4.7 shows that before intervention, performance of boys of experimental and control groups on drawing test was not significantly different (p = .67). After intervention, boys of experimental group performed significantly better than those of the control group on drawing test (p < .001). Gain scores of boys of experimental group on the drawing test were also significantly higher than those of the control group (p = .002).

Pretest scores of girls of control group on drawing test were significantly higher than those of the experimental group (p = .02). Posttest scores and gain scores of girls of
experimental group on drawing test, however, were significantly higher than those of the control group (p < .001 in both cases).

Effect size on gain scores on drawing test with 95 % confidence intervals was 0.62 [0.22, 1.01] for boys and 1.18 [0.80, 1.57] for girls.

Table 4.7 shows that performance of boys of experimental group on conservation test was significantly better than those of the control group before and after intervention (p = .03 and p < .001 respectively). However, gain scores of the boys of experimental group on conservation test were also significantly higher than those of the control group (p = .007).

Before intervention, girls of experimental and control groups were not significantly different on conservation test (p = .82). After intervention, girls of experimental group were significantly better that those of the control group on conservation test (p = .001). Gain scores of girls of experimental group on conservation test were also significantly higher than those of the control group (p < .001).

Effect size on gain scores on conservation test with 95 % confidence intervals was 1.04 [0.35, 1.73] in boys and 1.33 [0.68, 1.97] in girls.

These findings pertaining to the research question 4 showed that the effect of science activities was significant for the development of thinking skills of both boys and girls. However, the values of the effect sizes revealed that the intervention was relatively more effective for the development of thinking skills of girls than that of the boys.

Gain scores of boys and girls of experimental and control groups on drawing and conservation tests were shown in Fig. 4.4.
Age Wise Comparison

This section describes the effect of intervention on the children of different age. Scores of children of age 5+, 6+, 7+ and 8+ years on drawing and conservation tests were analyzed to identify the effect of intervention on the cognitive development of children at different ages. Scores of children of experimental and control groups at different age on drawing and conservation tests are given in Table 4.8.
Table 4.8

*Effect of Intervention on Drawing and Conservation Tests of Children at Different Age*

<table>
<thead>
<tr>
<th>Age</th>
<th>Group</th>
<th>Drawing test</th>
<th>Conservation test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pretest</td>
<td>Posttest</td>
</tr>
<tr>
<td>5+</td>
<td>Experimental</td>
<td>n = 18</td>
<td>M = 9.22</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>n = 23</td>
<td>M = 9.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 4.57</td>
<td>M = 5.53</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 4.23</td>
<td>M = 1.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 4.78</td>
<td>M = 1.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p = .88</td>
<td>M = 0.05</td>
</tr>
<tr>
<td>6+</td>
<td>Experimental</td>
<td>n = 43</td>
<td>M = 10.98</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>n = 46</td>
<td>M = 11.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 4.86</td>
<td>M = 4.65</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 3.23</td>
<td>M = 4.98</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 4.23</td>
<td>M = .91</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ES = 1.05</td>
<td>M = 0.60</td>
</tr>
<tr>
<td>7+</td>
<td>Experimental</td>
<td>n = 25</td>
<td>M = 12.04</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>n = 42</td>
<td>M = 13.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 4.29</td>
<td>M = 4.42</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 2.96</td>
<td>M = 3.85</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 3.75</td>
<td>M = 2.87</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 2.13</td>
<td>M = .27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ES = 0.90</td>
<td>M = 0.39</td>
</tr>
<tr>
<td>8+</td>
<td>Experimental</td>
<td>n = 11</td>
<td>M = 13.45</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>n = 17</td>
<td>M = 17.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 5.43</td>
<td>M = 2.77</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 4.53</td>
<td>M = 0.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD = 2.90</td>
<td>M = 2.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ES = .03</td>
<td>M = .98</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ES = 1.08</td>
<td>M = 1.88</td>
</tr>
</tbody>
</table>
Table 4.8 shows that children of experimental and control groups at age 5+ were not significantly different on drawing test before and after intervention (p = .88 and p = .10 respectively). Gain scores of children of experimental group were higher than those of the control group, but the mean difference were not significant (p = .11).

Children of experimental and control groups at age 6+ were not significantly different on drawing test before intervention (p = .91). Posttest scores as well as gain scores of children of experimental group on drawing test were significantly higher than those of the control group (p < .001 and p < .001 respectively).

Pretest scores of children of experimental and control groups at age 7+ on drawing test were not significantly different (p = .27). Posttest scores and gain scores of children of experimental group on drawing test, however, were significantly higher than those of the control group (p = .006 and p = .001 respectively).

At age 8+, scores of children of control group on drawing test were significantly higher than those of the experimental group before intervention (p = .03). After intervention, children of both groups were not significantly different with respect to scores on drawing test (p = .98). Gain scores of children of experimental group, however, were significantly higher than those of the control group (p = .008).

Effect size on gain scores on drawing test with 95% confidence intervals was 0.50 [-0.13, 1.12] in children of 5+ age group, 1.05 [0.60, 1.49] in children of 6+ age group, 0.90 [0.39, 1.42] in children of 7+ age group, and 1.08 [0.27, 1.88] in children of 8+ age group.

Table 4.8 shows that in 5+ age group, children of experimental and control groups were not significantly different on conservation test before intervention (p = .28). After intervention, children of experimental group were significantly better than those of the control group on conservation test (p = .04). Gain scores of children of experimental
group on conservation test though were higher than those of the control group, but the mean difference was not significant (p = .23).

Children of experimental and control groups at age 6+ were not significantly different on conservation test before intervention (p = .58). Posttest scores and gain scores of children of experimental group on conservation test were significantly higher than those of the control group (p < .001 and p < .001 respectively).

Pretest scores of children of experimental and control groups at age 7+ on conservation test were not significantly different (p = 0.47). Posttest scores and gain scores of experimental group on conservation test, however, were significantly higher than those of the control group (p < .001 and p = .002 respectively).

In children at age 8+, pretest scores and posttest scores of experimental and control groups were not significantly different on conservation test (p = .55 and p = .06 respectively). Gain scores of children of experimental group were higher than those of the control group, but the mean difference was not significant (and p = .22).

Values of effect sizes on gain scores on conservation test with 95 % confidence intervals were 0.72 [-0.51, 1.94] in children of age 5+ year, 1.61 [0.80, 2.42] in children of age 6+ year, 1.29 [0.48, 2.10] in children of age 7+ year, and 0.75 [-0.51, 2.02] in children of age 8+ year.

These findings pertained to research question 5 and revealed that science activities differently affected the development of thinking skills of children at different age. Effect of intervention on the drawing test was significant and high at the age group 6+, 7+, and 8+. For the conservation test, it was significant and high at the age group 6+ and 7+. In rest of the cases, the effect of intervention was insignificant and medium. Moreover, it can be noticed that the effect size on gain scores on conservation test was the highest at the age 6+, which dropped gradually in 7+ and 8+ age groups.
Gain scores of children of experimental and control groups at different age on drawing and conservation tests are shown in Fig. 4.5.

Figure 4.5. Gain scores of children of experimental and control groups at different age on drawing and conservation tests.

Age wise comparison was made for boys and girls as well to see the effect of intervention on the development of thinking skills of boys and girls at different age. Scores of boys of experimental and control groups at different ages on drawing and conservation tests are given in Table 4.9.
Table 4.9
Effect of Intervention on Drawing and Conservation Tests of Boys at Different Age

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<th>Conservation test</th>
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Table 4.9 shows that at age 5+, pretest scores and posttest scores of boys of experimental and control groups were not significantly different (p = .70 and p = .83 respectively). Gain scores of boys of experimental group on drawing test were higher than those of the control group, but the mean difference was not significant (p = .85).

Performance of boys of experimental and control groups at age 6+ on drawing test was not significantly different before intervention (p = .14). Posttest scores and gain scores of boys of experimental group on drawing test were significantly higher than those of the control group (p < .001 and p = .04 respectively).

In age group 7+, pretest scores, posttest scores, and gain scores of boys of experimental and control groups on drawing test were not significantly different (p = .87, p = .07 and p = .08 respectively).

Pretest scores, posttest scores, and gain scores of boys of experimental and control groups at age 8+ were not significantly different on drawing test (p = .22, p = .97, and p = .15 respectively).

In boys, the effect size on gain scores on drawing test with 95 % confidence intervals was 0.09 [-0.89, 1.07] in 5+ age group, 0.64 [0.04, 1.24] in 6+ age group, 0.70 [-0.09, 1.49] in 7+ age group, and 0.86 [-0.36, 2.08] in 8+ age group.

Table 4.9 shows that pretest scores, posttest scores, and gain scores of boys of experimental and control groups at age 5+ were not significantly different on conservation test (p = .37, p = .06 and p = .54 respectively).

In 6+ age group, performance of boys of experimental and control groups on conservation test was not significantly different at the time of pretest (p = .25). Posttest scores and gain scores of boys of experimental group on conservation test, however, were significantly higher than those of the control group (p < .001 and p = .001 respectively).

Pretest scores, posttest scores, and gain scores of boys of experimental and control
groups at age 7+ on conservation test were not significantly different (p = .35, p = .06, and p = .21 respectively).

There was only one boy in experimental group with age 8+, when comparison was made on conservation test. Pretest scores, posttest scores, and gain scores of boys of experimental and control groups at age 8+ on conservation test were not significantly different (p = .32, p = .73, and p = .06 respectively).

In boys, the values of effect sizes on gain scores on conservation test with 95% confidence intervals were 0.46 [-1.35, 2.27] in 5+ age group, 1.93 [0.74, 3.11] in 6+ age group, 0.75 [-0.48, 1.98] in 7+ age group, and -2.59 [-5.47, 0.30] in 8+ age group.

These findings pertaining to the research question 4 and 5 describe that intervention through science activities differently affected the development of thinking skills of boys at various age. Intervention was significantly effective for boys only at the age 6+. At this age, medium effect size on gain scores on the drawing test and high effect size on gain scores on the conservation test was found. Moreover, the effect size on gain scores on conservation test was the highest at age 6+, which declined gradually in the age groups 7+ and 8+.

Gain scores of boys of experimental and control groups at different age on drawing and conservation tests are presented in Fig. 4.6.
Figure 4.6. Gain scores of boys of experimental and control groups at different age on drawing and conservation tests.

Pretest, posttest, and gain scores of girls of experimental and control groups at different age on drawing and conservation tests are given in Table 4.10.
Table 4.10
Effect of Intervention on Drawing and Conservation Tests of Girls at Different Age

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Table 4.10 shows that at age 5+, performance of girls of experimental and control groups on drawing test was not significantly different before intervention ($p = .77$). After intervention, girls of experimental group performed significantly better than those of the control group ($p = .04$). However, gain scores of girls of experimental group on drawing test were not significantly higher than those of the control group ($p = .06$).

In 6+ age group, girls of experimental and control groups were not significantly different before intervention with respect to scores on drawing test ($p = .13$). Posttest scores and gain scores of girls of experimental group on drawing test were significantly higher than those of the control group ($p = .001$ and $p < .001$ respectively).

Performance of girls of experimental and control groups at age 7+ on drawing test was not significantly different before intervention ($p = .19$). Posttest scores of girls of experimental group were not significantly higher than those of the control group ($p = .10$). However, gain scores of girls of experimental group were significantly higher than those of the control group ($p = .003$).

In 8+ age group, girls of experimental and control groups were not significantly different on drawing test before and after intervention ($p = .10$ and $p = .84$ respectively). Gain scores of girls of experimental group were higher than those of the control group, though the mean difference was not significant ($p = .06$).

In girls, the effect size on gain scores on drawing test with 95% confidence intervals was 0.77 [-0.06, 1.60] in 5+ age group, 1.38 [0.70, 2.07] in 6+ age group, 1.02 [0.34, 1.71] in 7+ age group, and 1.12 [0.03, 2.21] in 8+ age group.

Table 4.10 shows that at age 5+, girls of experimental and control groups were not different on conservation test before intervention (M=0.00 and SD=0.00 for both experimental and control groups). Posttest scores and gain scores of girls of experimental group were higher than those of the control group, but the mean differences were not
significant \( (p = .37 \text{ in both cases}) \).

At age 6\(^+\), performance of girls of experimental and control groups on conservation test was not significantly different before intervention \( (p = .59) \). After intervention, girls of experimental group were better than those of the control group on conservation test, but the difference was not significant \( (p = .06) \). However, gains scores of girls of experimental group on conservation test were significantly higher than those of the control group \( (p = .03) \).

In 7\(^+\) age group, performance of girls of experimental and control groups on conservation test was not significantly different before intervention \( (p = .9) \). Posttest scores and gain scores of girls of experimental groups on conservation test were significantly higher than those of the control group \( (p = .004 \text{ in both cases}) \).

At age 8\(^+\), girls of experimental and control groups were not significantly different on conservation test before intervention \( (p = 1.00) \). After intervention, scores of girls of experimental group on conservation test were higher than those of the control group, but the mean difference was not significant \( (p = .18) \). Similarly, gain scores of girls of experimental group on conservation test were higher than those of the control group, but again the mean difference was not significant \( (p = .10) \).

For girls, the effect size on gain scores on conservation test with 95% confidence intervals was 0.65 [-0.99, 2.29] at 5\(^+\) age, 1.17 [0.08, 2.27] at 6\(^+\) age, 1.57 [0.48, 2.66] at 7\(^+\) age, and 1.31 [-0.33, 2.96] at 8\(^+\) age.

These findings pertaining to the research question 4 and 5 showed that science activities differently affected the development of thinking skills of girls at different age. The effect of intervention on both drawing and conservation tests was significant at age 6\(^+\) and 7\(^+\), but not at age 5\(^+\) and age 8\(^+\). Intervention was significantly and highly effective for the development of thinking skills of girls at age 6\(^+\) and 7\(^+\).
Gain scores of girls of experimental and control groups at different age on drawing and conservation tests are given in Fig. 4.7.

*Figure 4.7. Gain scores of girls of experimental and control groups at different age on drawing and conservation tests.*
CHAPTER V

Results and Discussion

Concerns regarding developing thinking skills among the students have been growing through out the world. Deficiencies in the thinking skills of the student led the researchers towards the development of thinking skills interventions. The present study aimed at developing thinking skills of early school children through science activities and to ascertain the factors that contribute towards the development of thinking skills at this level. In contrast to intelligence tradition, thinking skill tradition recognizes that many of the cognitive abilities that are usually considered to be linked with intelligence are teachable and they should be taught directly and overtly. Intellectual capacities of a person can be developed in the same way as motor skills can be polished with the conscious effort of the person and practice (Fisher, 2005). Thinking skills intervention programs were being originated through out the world at the end of twentieth century. A variety of thinking skills interventions representing different approaches has been developed, which vary on the scale of effectiveness. Cognitive Acceleration is one of the successful thinking skill intervention programs.

Effect of thinking skill interventions varies depending upon the context and the age level of the students (Higgins et al., 2004) and there is a need to identify the areas and age groups where the effect of intervention is more distinguished (Higgins et al., 2005). The current study was conducted in this perspective. Cognitive Acceleration through Science Education at Key Stage 1 (CASE @ KS 1) program was implemented on the children of grade 1 in Pakistan. Children of age 5+, 6+, 7+ and 8+ years were present in the grade 1. The variety of age group among children of grade 1 in Pakistan provided the researcher the opportunity to explore the effect of thinking skill intervention on the children of different age. This was the important feature of the current study that was not
reported before as in UK where CASE @ KS 1 program was devised and conducted, children of only age 5-6 were present in grade 1.

Quasi experimental design was used in the study. A total of 101 experimental group and 130 control group children from four public and five private sector schools participated in the study. Thirty science activities (‘Let’s Think!’) were conducted through one academic year as intervention. Schemata addressed in the activities were: Seriation, Classification, Time Sequence, Spatial Perception, Causation, Theory of Mind and Concrete Modeling. Activities related to schema of time sequence were adapted according to local context. Two cognitive development tests were used as pre and posttest: Drawing test and the conservation test. The purpose of drawing test, that intended to measure the schema of spatial perception, was to observe the effect of intervention on the schema addressed in the intervention program i.e., the possibility of near transfer through intervention. Conservation test was used in order to examine the effect of intervention on the schema other than those addressed in the intervention program i.e., the possibility of far transfer through intervention.

Data were analyzed by using independent sample t-test and Hedge’s g effect size. Results of the study are presented in the following section while addressing the research questions of the study.

**Answers to the Research Questions**

**Answer to research question 1: Effect of science activities on the development of the schema addressed in intervention program (spatial perception).** Before intervention, experimental and control groups were not significantly different with respect to their scores on drawing test (p = .14). Posttest scores and gain scores of experimental group on drawing test, however, were significantly higher than those of the control group (p < .001 and p < .001 respectively). Effect size on gain scores on drawing
test with 95% confidence intervals was 0.92 [0.65, 1.19] (Table 4.1).

These findings pertained to the research questions 1: “To what extent science activities can accelerate the development of the schema addressed in intervention program (spatial perception)?” It can be concluded from these findings that intervention through science activities was significantly and highly effective for accelerating the development of the schema of spatial perception; the schema that was addressed in the intervention program and therefore caused near transfer.

Answer to research question 2: Effect of science activities on the development of the schema other than those addressed in the intervention program (conservation). Pretest scores of experimental and control groups on conservation test were not significantly different (p = .18). However, posttest scores and gain scores of experimental group on conservation test were significantly higher than those of the control group (p < .001 in both cases). Effect size on gain scores on conservation test with 95% confidence intervals was 1.22 [0.75, 1.70] (Table 4.1).

These findings pertained to the research questions 2: “To what extent science activities can accelerate the development of the schema other than those addressed in the intervention program (conservation)?” Findings showed that the science activities were significantly and highly effective for accelerating the development of the schema of conservation; the schema that was not addressed in the intervention program and hence caused far transfer as well.

School wise comparison. Comparisons between the experimental and the control groups were made for the schools 1, 2 and 3, where both experimental and control groups were present. The effect of intervention on the development of thinking skills of children in these three schools was as follows:

School 1. In school 1, performance of control group on drawing test was
significantly better than that of the experimental group before intervention (p = .003). After intervention, scores of experimental group on drawing test were not significantly higher than those of the control group (p = .54). However, gain scores of experimental group on drawing test were significantly higher than those of the control group (p < .001). Effect size on gain scores on drawing test with 95 % confidence intervals was 1.06 [0.49, 1.63].

Pretest scores of experimental and control groups on conservation test were not significantly different (p = .99). Posttest scores and gains scores of experimental group on conservation test, however, were significantly higher than those of the control group (p = .01 and p = .005 respectively). Effect size on gain scores on conservation test with 95 % confidence intervals was 1.43 [0.42, 2.44] (Table 4.2).

**School 2.** Pretest scores of experimental and control groups of school 2 on drawing test were not significantly different (p = .60). Posttest scores and gain scores of experimental group on drawing test, however, were significantly higher than those of the control group (p < .001 and p = .004 respectively). Effect size on gain scores on drawing test with 95 % confidence intervals was 0.71 [0.22, 1.19].

Performance of experimental and control groups on conservation test was not significantly different before intervention (p = .34). However, posttest scores and gain scores of experimental group on conservation test were significantly higher than those of the control group (p = .003 and p = .01 respectively). Effect size on gain scores on conservation test with 95 % confidence intervals was 1.08 [0.22, 1.94] (Table 4.3).

**School 3.** Experimental and control groups in school 3 were not significantly different on drawing test before and after intervention (p = .86 and p = .06 respectively). Gain scores of experimental group on drawing test were higher than those of the control group, but the mean difference was not significant (p = .12). Effect size on gain scores on
drawing test with 95 % confidence intervals was 0.48 [-0.14, 1.09].

Performance of experimental and control groups on conservation test was not significantly different before intervention (p = .94). Posttest scores and gain scores of experimental group on conservation test were also significantly higher than those of the control group (p = .006 and p = .004 respectively). Effect size on gain scores on conservation test with 95 % confidence intervals was 1.30 [0.21, 2.38] (Table 4.4).

In nutshell, gain scores of experimental groups on conservation test were significantly higher than those of the control groups in all the three schools. Gain scores of experimental group on drawing test were significantly higher than those of the control group in school 1 and 2. In school 3, gain scores of experimental group on drawing test though were higher than those of the control group but the mean difference was not significant.

**Answer to the research question 3: Effect of science activities on the development of thinking skills of children of public and private sector schools.** The effect of intervention on the development of thinking skills of children of public and private sector schools was as follows:

**Drawing test.** In public sector schools, pretest scores of experimental and control groups were not significantly different (p = .09). However, posttest scores and gain scores of experimental group on drawing test were significantly higher than those of the control group (p = .002 and p < .001 respectively).

In private sector schools, scores of experimental and control groups on drawing test were not significantly different before intervention (p = .92). Posttest scores and gain scores of experimental group, however, were significantly higher than those of the control group (p < .001 in both cases).

Effect size on gain scores on drawing test with 95 % confidence intervals was
In public and private sector schools (Table 4.6).

**Conservation test.** In public sector schools, performance of experimental and control groups on conservation test was not significantly different before intervention (p = .51). Posttest scores and gain scores of experimental group on conservation test, however, were significantly higher than those of the control group (p < .001 in both cases).

In private sector schools, experimental and control groups were not significantly different before intervention with respect to their performance on conservation test (p = .15). Posttest scores and gain scores of experimental group on conservation test, however, were significantly higher than those of the control group (p < .001 and p = .002 respectively).

Effect size on gain scores on conservation test with 95% confidence intervals was 1.17 [0.52, 1.82] in public sector schools and 1.21 [0.52, 1.90] in private sector schools (Table 4.6).

These findings pertained to the research question 3: “Do the science activities affect the development of thinking skills of children of public and private sector schools in the same way?” Gain scores of experimental group on drawing and conservation tests were significantly higher than those of the control groups in both public and private sector schools. Values of effect size on gain scores on drawing and conservation tests were also high in both sectors. Hence, science activities were significantly and highly effective for the development of thinking skills of children of both sectors.

However, when values of effect sizes on gain scores on the drawing and the conservation tests of public and private sector schools were compared, a slight difference was observed that was in the favor of private sector schools. Therefore, it can be concluded that the effect of intervention was slightly higher on the thinking skills of
children of private sector schools.

**Answer to the research question 4: Effect of science activities on the development of thinking skills of boys and girls.** Effect of intervention on the drawing and conservation tests of boys and girls was as follows:

**Drawing test.** Performance of boys of experimental and control groups on drawing test was not significantly different before intervention ($p = .67$). However, boys of experimental group were significantly better than those of the control group with respect to posttest scores ($p < .001$) and gain scores ($p = .002$) on drawing test.

Girls of control group were significantly better than those of the experimental group on drawing test before intervention ($p = .02$). Girls of experimental group, however, were significantly better than those of the control group with respect to posttest scores and gain scores on drawing test ($p < .001$ in both cases).

Effect size on gain scores on drawing test with 95% confidence intervals was $0.62 [0.22, 1.01]$ for boys and $1.18 [0.80, 1.57]$ for girls.

**Conservation test.** Performance of boys of experimental group on conservation test was significantly better than those of the control group before and after intervention ($p = .03$ and $p < .001$ respectively). However, gain scores of the boys of experimental group were also significantly higher than those of the control group ($p = .007$).

Performance of girls of experimental and control groups were not significantly different on conservation test before intervention ($p = .82$). However, girls of experimental group were significantly better that those of the control group with respect to posttest scores ($p = .001$) and gain scores ($p < .001$) on conservation test.

Effect size on gain scores on conservation test with 95% confidence intervals was $1.04 [0.35, 1.73]$ in boys and $1.33 [0.68, 1.97]$ in girls (Table 4.7).

These findings pertained to the research question 4: “Do the science activities
affect the development of thinking skills of boys and girls in the same way?” Gain scores of experimental group on drawing and conservation tests were significantly higher than those of the control groups in both boys and girls. Value of effect size on gain scores on drawing test was high in girls and medium in boys. Values of effect sizes on gain scores on conservation test were high in both boys and girls. However, when the values of effect sizes on conservation test were compared, it was higher in girls than the boys. Hence, the effect of intervention for the development of thinking skills was greater in girls as compared to boys, though it was significant for the children of both genders.

**Answer to the research question 5: Effect of science activities on the children of different age.** Effect of intervention on the drawing and conservation tests of children at different age was as follows:

**Drawing test.** Children of experimental and control groups at age 5+ were not significantly different on drawing test before and after intervention (p = .88 and p = .10 respectively). Gain scores of children of experimental group on drawing test were higher than those of the control group but the mean difference were not significant (p = .11).

Children of experimental and control groups at age 6+ were not significantly different on drawing test before intervention (p = .91). Posttest scores as well as gain scores of children of experimental group on drawing test were significantly higher than those of the control group (p < .001 in both cases).

Pretest scores of children of experimental and control groups at age 7+ on drawing test were not significantly different (p = .27). Posttest scores and gain scores of children of experimental group on drawing test, however, were significantly higher than those of the control group (p = .006 and p = .001 respectively).

At age 8+, children of control group were significantly better than those of the experimental group with respect to their pretest scores on drawing test (p = .03). Posttest
scores of children of both groups on drawing test were not significantly different (p = .98). However, gain scores of children of experimental group on drawing test were significantly higher than those of the control group (p = .008).

Effect size on gain scores on drawing test with 95% confidence intervals was 0.50 [-0.13, 1.12] in children of 5+ age group, 1.05 [0.60, 1.49] in children of 6+ age group, 0.90 [0.39, 1.42] in children of 7+ age group, and 1.08 [0.27, 1.88] in children of 8+ age group (Table 4.8).

Conservation test. In 5+ age group, children of experimental and control groups were not significantly different on conservation test before intervention (p = .28). After intervention, children of experimental group were significantly better than those of the control group on conservation test (p = .04). Gain scores of children of experimental group on conservation test were higher than those of the control group but the mean difference was not significant (p = .23).

Children of experimental and control groups at age 6+ were not significantly different on conservation test before intervention (p = .58). However, posttest scores and gain scores of children of experimental group on conservation test were significantly higher than those of the control group (p < .001 and p < .001 respectively).

Pretest scores of children of experimental and control groups at age 7+ on conservation test were not significantly different (p = 0.47). Posttest scores and gain scores of experimental group on conservation test, however, were significantly higher than those of the control group (p < .001 and p = .002 respectively).

In children at age 8+, pretest scores and posttest scores of experimental and control groups were not significantly different on conservation test (p = .55 and p = .06 respectively). Gain scores of children of experimental group on conservation test were higher than those of the control group with insignificant mean difference (and p = .22).
Values of effect sizes on gain scores on conservation test with 95% confidence intervals were 0.72 [-0.51, 1.94] in children of age 5+ year, 1.61 [0.80, 2.42] in children of age 6+ year, 1.29 [0.48, 2.10] in children of age 7+ year, and 0.75 [-0.51, 2.02] in children of age 8+ year (Table 4.8).

These findings pertained to the research question 5: “In which age group of early school children science activities are most effective for the development of thinking skills?”. It is evident from the above mentioned findings that the effect of science activities was different for the development of thinking skills of children at different age. Gain scores of experimental group on drawing test were significantly higher than those of the control group at age 6+, 7+ and 8+. Gain scores of experimental group on conservation test were significantly higher than the control group at age 6+ and 7+. All these significant effects were high as revealed by values of effect size. It can be concluded that at the ages 6+ and 7+, intervention was significantly and highly effective for the development of thinking skills of children.

**Effect of science activities on the boys of different age.** Effect of science activities on the drawing and conservation tests of boys of different age was as follows:

**Drawing test.** At age 5+, pretest scores, posttest scores, and gain scores of boys of experimental and control groups were not significantly different (p = .70, p = .83, and p = .85 respectively).

Performance of boys of experimental and control groups at age 6+ on drawing test was not significantly different before intervention (p = .14). Posttest scores and gain scores of boys of experimental group on drawing test were significantly higher than those of the control group (p < .001 and p = .04 respectively).

In age group 7+, pretest scores, posttest scores, and gain scores of boys of experimental and control groups on drawing test were not significantly different (p = .87,
p = .07 and p = .08 respectively).

Pretest scores, posttest scores, and gain scores of boys of experimental and control groups at age 8+ were not significantly different on drawing test (p = .22, p = .97, and p = .15 respectively).

In boys, the effect size on gain scores on drawing test with 95% confidence intervals was 0.09 [-0.89, 1.07] in 5+ age group, 0.64 [0.04, 1.24] in 6+ age group, 0.70 [-0.09, 1.49] in 7+ age group, and 0.86 [-0.36, 2.08] in 8+ age group (Table 4.9).

**Conservation test.** Pretest scores, posttest scores, and gain scores of boys of experimental and control groups at age 5+ were not significantly different on conservation test (p = .37, p = .06 and p = .54 respectively).

In 6+ age group, performance of boys of experimental and control groups on conservation test was not significantly different at the time of pretest (p = .25). Posttest scores and gain scores of boys of experimental group on conservation test, however, were significantly higher than those of the control group (p < .001 and p = .001 respectively).

Pretest scores, posttest scores, and gain scores of boys of experimental and control groups at age 7+ on conservation test were not significantly different (p = .35, p = .06, and p = .21 respectively).

There was only one boy in experimental group with age 8+, when comparison was made on conservation test. Pretest scores, posttest scores, and gain scores of boys of experimental and control groups at age 8+ on conservation test were not significantly different (p = .32, p = .73, and p = .06 respectively).

In boys, the value of effect size on gain scores on conservation test with 95% confidence intervals was 0.46 [-1.35, 2.27] at age 5+, 1.93 [0.74, 3.11] at age 6+, 0.75 [-0.48, 1.98] at age 7+, and -2.59 [-5.47, 0.30] at age 8+ (Table 4.9).

**Effect of science activities on the girls of different age.** Effect of science
activities on drawing and conservation tests of girls of different age was as follows:

**Drawing test.** At age 5+, performance of girls of experimental and control groups on drawing test was not significantly different before intervention (p = .77). After intervention, girls of experimental group performed significantly better than those of the control group (p = .04). However, gain scores of girls of experimental group on drawing test were not significantly higher than those of the control group (p = .06).

In 6+ age group, girls of experimental and control groups were not significantly different before intervention with respect to scores on drawing test (p = .13). Posttest scores and gain scores of girls of experimental group on drawing test were significantly higher than those of the control group (p = .001 and p < .001 respectively).

Performance of girls of experimental and control groups at age 7+ on drawing test was not significantly different before intervention (p = .19). Posttest scores of girls of experimental group were not significantly higher than those of the control group (p = .10). However, gain scores of girls of experimental group were significantly higher than those of the control group (p = .003).

In 8+ age group, girls of experimental and control groups were not significantly different on drawing test before and after intervention (p = .10 and p = .84 respectively). Gain scores of girls of experimental group were higher than those of the control group, though the mean difference was not significant (p = .06).

In girls, the effect size on gain scores on drawing test with 95 % confidence intervals was 0.77 [-0.06, 1.60] in 5+ age group, 1.38 [0.70, 2.07] in 6+ age group, 1.02 [0.34, 1.71] in 7+ age group, and 1.12 [0.03, 2.21] in 8+ age group (Table 4.10).

**Conservation test.** At age 5+, girls of experimental and control groups were not different on conservation test before intervention (M=0.00 and SD=0.00 for both experimental and control groups). Posttest scores and gain scores of girls of experimental
group were higher than those of the control group, but the mean differences were not significant (p = .37 in both cases).

At age 6+, performance of girls of experimental and control groups on conservation test was not significantly different before and after intervention (p = .59 and p = .06 respectively). However, gains scores of girls of experimental group on conservation test were significantly higher than those of the control group (p = .03).

In 7+ age group, performance of girls of experimental and control groups on conservation test was not significantly different before intervention (p = .9). Posttest scores and gain scores of girls of experimental groups on conservation test were significantly higher than those of the control group (p = .004 in both cases).

At age 8+, girls of experimental and control groups were not significantly different on conservation test before and after intervention (p = 1.00 and p = .18 respectively). Gain scores of girls of experimental group on conservation test were higher than those of the control group, but the mean difference was not significant (p = .10).

For girls, the effect size on gain scores on conservation test with 95% confidence intervals was 0.65 [-0.99, 2.29] at 5+ age, 1.17 [0.08, 2.27] at 6+ age, 1.57 [0.48, 2.66] at 7+ age, and 1.31 [-0.33, 2.96] at 8+ age.

The above mentioned findings pertaining to research question 4 and 5 reveal that science activities differently affect the development of thinking skills of boys and girls at various age groups. In case of boys, the effect of intervention on both drawing and conservation tests was significant only at the age 6+. A medium effect on drawing and high effect on conservation test was observed in the boys at this age. For girls, intervention was significantly and highly effective in age groups 6+ and 7+. This significant and high effect was observed both on drawing and conservation tests. Hence, the intervention was found to be significantly effective for development of thinking skills.
of boys of only age 6+ and girls of age 6+ and 7+. It can be concluded that the appropriate age in which intervention leads to the significant effect on the thinking skills of girls is 6+ and 7+ in contrast to only 6+ for boys.

**Discussion**

The current study aimed at exploring the effect of science activities based on Cognitive Acceleration on the development of thinking skills of early school children in Pakistan and exploring the factors that contribute towards development of thinking skills at this level. A total of 40 comparisons were made in the current study. These comparisons were made to find out the effect of science activities on the thinking schema addressed in the intervention program, the effect of science activities on the thinking schema other than those addressed in the intervention program, the effect of intervention in different schools, the effect of intervention on the children of public and private sector schools, the effect of intervention on the children of different gender, the effect of intervention on the children of different age groups and the effect of intervention on the boys and girls at different age. Experimental group was significantly better than the control group in 26 comparisons, whereas the difference was not significant in the rest of the 14 comparisons. Effect sizes were high in 26 cases, medium in 10 cases, low in three cases and negative in one case.

Higgins et al. (2005) reported average medium effect size of 0.62 when the impact of thinking skill interventions was measured on cognitive dimensions in contrast to average high effect size of 1.44 when the impact was measured on affective dimensions. He reported four Cognitive Acceleration studies in his meta-analysis study and the average effect size of these studies was 0.61 in contrast to average effect size of 0.58 in the studies on instrumental enrichment and average effect size of 0.96 in the studies on metacognitive strategies. He reported five intervention studies conducted in the
context of science. The average effect size of these studies was 0.78 in contrast to the average effect size of 0.89 when interventions were developed in the context of mathematics and the average effect size of 0.48 when interventions were developed in the context of reading. However, on the basis of CASE II study, Shayer (1999) reported high effect sizes of 1.5 to 2 standard deviations on the Cognitive Measures, in Cognitive Acceleration and in the Context of science.

Given below is the discussion of the results with reference to the research questions of the study.

**Effect of science activities on the thinking schema addressed in the intervention program.** Science activities used in the study were related to the schema that children form during concrete operational stage. The schemata that were addressed in the intervention program include: **Seriation, Classification, Time Sequence, Spatial Perception, Causality** and **Rules of Games** (consists of schema **Theory of Mind** and **Concrete Modeling**). Drawing test that was measuring the schema of spatial perception, administered before and after the intervention to examine the effect of science activities on the schema addressed in intervention program. Results of the study showed that experimental group made significantly higher gains than the control group on the drawing test. Hence, the intervention significantly affected the development of schema that was addressed in the intervention program (spatial perception) and caused near transfer.

Magnitude of the effect can be viewed in two ways. Firstly, value of effect size showed that the effect of science activities was high on the scores on drawing test. Secondly, the effect can be described in terms of development of substages of concrete operational level. At the time of pretest, average age of class one students was 6 years and 11 months and students were at late preoperational level as indicated by the scores on drawing test. After one year, at the time of posttest, the control group was at early
concrete operational level whereas experimental group was at mid concrete level as depicted by the scores on drawing test. The cognitive level of experimental and control groups at the time of pre and posttest was as mentioned in figure 5.1

![Figure 5.1. Cognitive level of experimental and control groups at the time of pre and posttest.](image)

Hence intervention through science activities accelerated the development of one substage of concrete operational level in the children of experimental group as compared to the children of control group.

**Effect of science activities on the thinking schema not addressed in the intervention program.** Intervention addressed the schema of **Seriation, Classification, Time Sequence, Spatial Perception, Causality and Rules of Game.** Schema of Conservation was not addressed in the intervention program. However, conservation test was administered as pre and posttest. The purpose of using this test was to observe the effect of intervention on far transfer i.e., on the development of schema not addressed in the intervention program. The results showed that experimental group made significantly
higher gains than the control group on conservation test. The value of effect size on gain scores on conservation test suggested that the effect of science activities was high on the development of schema of conservation. Hence, the intervention has significant and high effect on the development of the thinking schema not addressed in the intervention program, thus causing the far transfer as well.

School wise comparison. A total of six schools were included in the study. Independent sample t-test and effect size were not applied on the experimental and control groups belonging to different schools. Comparison between the experimental and control groups was made in schools 1, 2 and 3, where both experimental and control groups were present. Gain scores of experimental groups on conservation test were significantly higher than those of the control groups in all the three schools. In case of drawing test, gain scores of experimental groups were significantly higher than those of the control groups in school 1 and 2. In school 3, the gain scores of experimental group, though were higher than those of the control group, but the mean difference was not significant. The possible reasons for this insignificant difference may be the following.

In school 3, due to some administrative reasons, initially separated experimental and control groups, were made to sit together in the same room despite the fact they were receiving instructions separately. Moreover the teacher who was engaged in conducting the activities reported that initially some of the children of control group were disturbed for not being participated in the activities. Although after some time, they became settled according to the teacher, but there might be chances of discussions between the children of experimental and control group children regarding the activities. The pre existing close relationship between the children of experimental and control group children in this school noticed by the researcher may also be the reason of insignificant effect in this case.
The important factor which is worth mentioning here is that students of the experimental group performed significantly better on conservation test though the conditions were same for both tests. Hence it can be concluded that mere interaction with the children of experimental group and not actually receiving the treatment is helpful only in the near transfer and not in the far transfer as indicated by the scores of experimental and control groups on drawing and conservation tests.

**Effect of science activities on the thinking skills of children of different sector schools.** The scenario of public and private sector schools in Pakistan is discussed in detail in chapter two of the dissertation. The private schools included in the present study were not the elite class high quality schools, but were the inexpensive schools that were catering the middle income and even low income people. They were little different from public sector schools in terms of infrastructure and physical facilities. However, their comparative strength might be the more accountability of the teachers and low student-teacher ratio (21.6 for private sector vs. 30.75 for public sector in the current study) and hence more time spent per student.

Results of the study showed that both in public and private sector schools, gain scores of experimental group on drawing and conservation tests were significantly higher than those of the control group. In both public and private sector schools, values of effect size on gain scores on drawing and conservation tests were high. Hence, in both public and private sector schools, the effect of intervention was significant and high on the drawing and conservation tests. However, when values of effect sizes on gain scores on drawing and conservation tests were compared in the schools of both sectors, a slight difference was observed that was in favor of private sector schools. Thus, the effect of intervention on the cognitive development was slightly higher in the children of private sector schools. This implies that effect of intervention can be enhanced if quality of
school environment is improved in terms of physical conditions and human interaction.

**Effect of science activities on the development of thinking skills of boys and girls.** In both boys and girls, gain scores of experimental groups on drawing and conservation tests were significantly higher than those of the control groups. Therefore, the intervention was significantly effective for the cognitive development of children of both genders.

A medium effect size for boys and high effect size for girls was found on the gain scores on drawing test. On conservation test, high effect sizes were observed both in boys and girls. However, the value of effect size on conservation test was also higher in girls than the boys. Hence, the effect of intervention on the drawing and conservation tests was significant in both boys and girls. Moreover, the effect of intervention on the cognitive development was greater in girls than the boys as suggested by the higher values of effect sizes in girls on both drawing and conservation tests. This greater effect of intervention on the cognitive development of girls than the boys was in line with the results of Shyer and Adey (2002) who also found higher values of effect sizes in girls compared to boys on drawing and conservation tests.

**Effect of science activities on the thinking skills of children of different age groups.** The effect of intervention for accelerating the development of formal operational thinking of children at different age was explored in the current study. CASE project was specially designed to explore the effect of intervention on children at age 11+ and 12+. Later on, effect of CASE intervention was also explored on age 10+ children in Korean study. The results of these studies revealed differential effects of intervention for the boys and girls at different age group.

Effect of CASE@KS1 study for the development of concrete operational thinking of children at different age was not reported previously. The reason is that both
CASE@KS1 project of Shyer and Adey (2002) and small scale (N=22) replication of CASE@KS1 in a rural area by Cattle and Howie (2008) were conducted on the year 1 children of UK with age 5+. The current study was conducted on the grade 1 children in Pakistan. Here, though the entry age for grade 1 is 5 years old, but due to low Net Enrolment Ratio (NER), admission is offered to elder children as well. Hence when at the time of pretest, ages of grade 1 children were calculated by using the date of births record of the children maintained by the schools, they were ranging from 62 to 125 months (M=83, SD = 11.4). The effect of CASE@KS1 study for the development of concrete operational thinking of children, and for the boys and girls at age 5+, 6+, 7+ and 8+ years was examined in the current study.

At the age 5+, gain scores of children of experimental group on drawing and conservation tests though were higher than those of the control group, but the mean differences were not significant in both cases. Values of effect sizes revealed medium effect of intervention on both of the tests. These findings can be compared with the findings of the study of Shyer and Adey (2002) as in that study, children receiving intervention were at age 5+. Shyer and Adey found significant effects of intervention on both drawing and conservation tests. In contrast to the findings of Shyer and Adey, the effect of cognitive acceleration was not significant on the children of age 5+ in the current study; though medium effect sizes on both tests were there. Small sample size of 5+ age group in the current study (N=41 for drawing test and N=11 for conservation test) partially explains for the results not being significant in the current study.

At the age 6+ and 7+, intervention was found both significantly and highly effective for the development of thinking skills of the children. The effect of intervention on drawing test was significant and high on the children of age 6+, 7+ and 8+. In case of conservation test, the effect of intervention was significant and high on the children of
age 6+ and 7+, but medium and non significant at the age 8+. Effects of intervention for the development of concrete operational thinking of children of age 6+, 7+ and 8+ were not reported previously and hence no studies were available for comparing these results of the current study.

An important feature worth mentioning was that the highest effect of intervention on conservation test was the highest at the age of 6+ and a decreasing trend in the values of effect sizes on the conservation test was observed with the increase in age among the children of age 6+, 7+ and 8+ years. This means that except for age group 5+, younger the age, the more the effect of intervention was on the far transfer i.e., on the development of thinking skills in the schema other than those addressed in the intervention program.

In other words, when considering the age 6+, 7+ and 8+, the younger the children, the more were the chances that intervention would affect the development of general cognitive ability of the children, while likelihood of far transfer decreases with the increase in age. On the other hand, significant and high effects of intervention on gain scores on drawing test of the children at age 6+, 7+ and 8+ convey that the effect of intervention on near transfer continues even with the increase in age.

The same pattern of effect of intervention on the drawing and conservation tests was observed in boys. The effect size on conservation test was highest at age group 6+, which declined gradually in age groups 7+ and 8+ years. On the other hand, effect size on the drawing test continued to increase with the increase in age. Again, it suggests that intervention provided to the boys at the age 6+ will more likely cause far transfer. In girls, however, no such patterns for the values of effect sizes were identified.

In boys, effect of intervention on drawing and conservation tests was significant only in the age group 6+. The effect was medium on drawing test and high on conservation test of boys at this age. In case of girls, effect of intervention on both
drawing and conservation tests was significant and high at the age group 6+ and 7+.

Hence, appropriate age at which intervention resulted in the significant effect on drawing
and conservation tests was found 6+ year for boys in contrast to 6+ and 7+ years for girls.
These critical ages of boys and girls must be given full attention by the parents, teachers
and other stakeholders.

The results pertaining to the effect of intervention on the thinking skills of
children of different age groups can be interpreted in terms of Epstein’s (1999 a; 1999 b)
findings, who identified 6-8 year age group as phase of rapid brain growth whereas age 4-
6 and 8-10 as the phases of plateau. Stimulating experiences in this phase of rapid brain
growth, according to him lead towards increased interconnectivity of human brain cells.
Hence, intervention provided during brain spurt phase proves to be more effective,
whereas remains relatively ineffective if provided during plateau phase. During plateau,
consolidation of already acquired concepts is possible but it is difficult to give new
concepts to children (Epstein, 1999 a).

Moreover, according to Epstein (n. d.), gender differences exist in the phases of
brain spurts of 2-4, 6-8, 10-12 and 14-16 years. In this regard, he discussed in detail the
brain spurt phases of 10-12 and 14-16 year and reported the striking differences. Gender
differences in 2-4 and 6-8 year phases, however, were not reported. Current study throws
some light on the gender differences in the brain spurt phase of 6-8 year. It can be
concluded from the results of the current study that the time span, in which thinking skill
interventions led to the significant effects and hence found more beneficial, was different
for boys and girls. Intervention was beneficial and significantly effective for girls at the
age 6+ and 7+ whereas for boys, it was significantly effective for shorter period of time
i.e., at age 6+ only.
Recommendations

Keeping in view the results and discussion, following recommendations are proposed.

1. Thinking skill programs aiming at development of general thinking ability of the children should be introduced at early school years. It will lead to their better learning and improved performance not only in academic sphere but in their general life as well. As it is found that cognitive acceleration is effective for developing thinking skill of children in the schema of spatial perception and conservation. Therefore it is highly recommended that cognitive acceleration should be introduced in Pakistani curriculum and schools so that cognitive development of the children can be accelerated. Institutes responsible for pre service and in-service teacher education programs should also incorporate the philosophy and methodology of cognitive acceleration in their scheme of studies and should enhance the capacity of the teachers to improve classroom practices.

2. Public and private schools, both should benefit of thinking skills intervention program as it was found to be significantly and highly effective in both types of schools. However, slightly higher effect sizes obtained in private sector schools suggest that effect of intervention can be enhanced if quality of school environment is improved in terms of physical conditions and human interaction.

3. The thinking skills intervention is recommended for both genders. Though the effect of intervention was more pronounced in the girls, statistics reveal that intervention significantly affected the cognitive development of both genders in near as well as far transfer.

4. Age 6+ should receive special attention by the parents and teachers, as the effect of intervention on far transfer was the highest at this age. Thinking skills
intervention introduced at this age would more likely lead towards the
development of general cognitive ability of the children.

5. The critical periods of boys and girls for significant effect of intervention on the
development of thinking skill should be fully utilized by parents, teachers,
curriculum developers, textbook writers and policy makers.

6. Intellectual stimulus should be provided to the boys at the age 6+ and to the girls
at the age 6+ and 7+, otherwise for the next few years there is less probability of
obtaining the significant effects of intervention for the development of thinking
skills of children.

7. While making separate comparisons for different age groups of children, sample
turned out to be small in some cases especially while comparing experimental and
control groups on conservation test. Hence it is recommended for the future
researchers to explore with larger sample the effect of thinking skills intervention
for accelerating the development of concrete operational level of children at
different age.
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Annexure B: Activity Pictures

Activity 6: Buttons
Schema: Classification
School 4
Activity 8: Cat and Rat
Schema: Time sequence
School 1
Activity 9: Cars
Schema: Classification
School 2
Activity 12: Routine of the day
Schema: Time sequence
School 4

Activity 14: Guess what?
Schema: Classification
School 1
Activity 15: Library Books
Schema: Seriation
School 1

Activity 17: Looking at shapes
Schema: Spatial perception
School 2
Activity 16 & 18
Crossroads I Crossroads II
Schema: Spatial perception
School 4
Activity 20: Rolling Bottles
Schema: Causality
Activity 21: Lion and rat
Schema: Time series
School 4

Activity 23: In this town
Schema: Rule of game
Activity 24: Making a game
Schema: Rule of game
School 4
Activity 27: Wolf and Girl
Schema: Time sequence
School 3