CHAPTER-II
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REVIEW OF RELATED LITERATURE

2.1 Introduction

Since the emergence of metacognition as a new notion considerable research has been carried out, with metacognitive dimensions holding either a central or a secondary position. Most of these projects shared the same anticipation, one of improving learning outcomes as a result of the practice of metacognition (Hacker et al., 1998). Over the years, metacognition has been related to a number of general cognitive abilities and aptitudes such as intelligence (Borkowski, 1985), general aptitude (Swanson, 1990), and memory (Pressley et al., 1985), or more subject specific areas such as mathematics (Schoenfeld, 1987) and reading (Cross and Paris, 1988). Of these areas, the one with the most explicit connection to metacognition was the broad area of thinking skills, based on the belief that for higher level thinking to be generalized students should be given opportunities to think about their own thinking. Most of these studies offered ample evidence of a positive impact of metacognitive activity on student thinking and learning (Nickerson et al., 1985; Perkins & Salomon, 1989), was supported by research reports from within science education.

Research in metacognition has covered mainly three components: (a) ‘knowledge about strategies’, which refers to knowledge about when, where and why different strategies should be used; (b) ‘strategy use’, referring to the children’s actual use of metacognitive strategies without instruction or prompts; and (c) ‘cognitive monitoring’, which is a metacognitive acquisition procedure needed for evaluating and changing strategy use and for determining the limits of the knowledge (Chmiliar, 1997). Among the conclusions reached by metacognitive research to date are that: (a) knowing about how knowing develops, (b) both children and adults often fail to monitor cognitions, and (c) some strategies are difficult to learn and easy to abandon (Garner and Alexander, 1989).

The fact that the link between metacognition and thinking skills encouraged application of the former to improve the latter has resulted in a number of researchers focusing on groups with learning difficulties. Feuerstein et al. (1980), for instance, worked with disadvantaged underachieving children in employing their Instrumental Enrichment, while Campione (1987) studied metacognition mainly in relation to
students with learning problems and sometimes with mentally retarded children. Others, on the contrary, focused on the importance of establishing the independence of metacognition from general aptitude. In one such study, Swanson (1990) investigated whether high levels of metacognitive knowledge about problem solving could compensate for overall aptitude. He found that highly metacognitive students outperformed less metacognitive students in problem-solving regardless of their overall aptitude level. In fact, he reported that high-metacognitive/low aptitude children performed significantly better than low-metacognitive children with higher overall aptitude scores. He concluded that high performance on the problem solving tasks is more closely related to children’s performance on the metacognitive measures than on the overall aptitude measures. This was a position that was previously supported by other studies in the literature (Minsky & Papert, 1984; Slife et al., 1985). Interest in metacognition over the past three decades has reportedly resulted in positive shifts in students’ learning outcomes, hence justifying the view that ‘effective learners operate best when they have insights into their own strengths and weaknesses and access to their own repertoires of learning’ (Brown, 1994). Interestingly, most of the work on metacognition was conducted in relation to students’ perceptions and beliefs regarding learning and the learning processes (Thomas et al., 1997). Focusing on the impact of metacognitive thinking on taught subject matter and on learners’ understanding was clearly overlooked.

Our understanding of the mechanisms and the nature of metacognition to date remains incomplete and controversial, living up to its description as ‘a many-headed monster’ (Brown, 1987). Central to the problems relating to metacognition is finding ways of recording and making available to others one’s metacognitive thoughts. Both identifying and ‘measuring’ metacognition currently rely heavily on researchers’ subjective interpretation in assessing what is cognitive and what is metacognitive. Attempts in this direction are usually restricted to the observable elements of one’s metacognitive thinking; that is, what one says and what one does. What remains unsaid by the researched could entail a richness of reflection that remains unexplored by researchers. More research is needed that will enhance our understanding on what constitutes metacognition, how it can be identified, and whether it can be taught and how. These are just a few of the questions that are important to metacognitive literature, irrespective of discipline.
In the case of science education, research in metacognition is practically at its infancy. The existence of unanswered questions such as those just listed is contributing towards the relatively limited volume of work currently available in science. Research available to date seems fragmented and in lack of coherence, for it is scattered in the three areas of physics, chemistry and biology, and across an age range that usually extends to university students or science teachers, often overlooking primary school ages. The diversity and heterogeneity of metacognitive studies in science also make the verification of reported findings and generalization of conclusions difficult, in essence restricting trust among science educators in the potentials of metacognition. Future research attempts should concentrate on explicitly and systematically studying the educational impact of reflective thinking on children’s science learning, ideally starting from an early age. Examining the role of metacognition in addressing and attempting to change children’s alternative explanatory frameworks, developing scientific investigating skills or enhancing transfer of scientific understanding are only a few exciting directions of enquiry that could benefit contemporary science education. The outcomes of such research will consequently justify or reject the inclusion of metacognitive thinking as a component of science curricula.

The notion of metacognition is largely unknown to the average science teacher. Those of them who happen to be familiar with the notion do not have the resources to facilitate implementation of metacognition in their teaching, or they do not have the authority to make such changes on curriculum and time allocation as to accommodate metacognition in their teaching. The current state of the literature on metacognition has already given signs of a theory–practice gap emerging, comprising extensive academic elaboration on the mechanisms of metacognitive thinking and rare attempts to bring this inside ordinary classrooms.

If metacognition is to find its way into the science classroom this decision has to be made by policy-making bodies, which will consequently facilitate ordinary teachers in their attempts to do so. The conduct of research on the use and training of metacognition in 'natural contexts' (Davidson et al., 1996) is one way of taking a step forward. Until such changes are brought about, the practice of metacognitive thinking in science education will rely heavily on the initiative of small groups of teachers, who will have to invent both the resources and the time for such engagement.
Having broadly sketched the scenery of general metacognitive research, attention is now drawn to three projects that were either partly or exclusively conducted in the field of science education. These projects are the Project to Enhance Effective Learning (PEEL) in Australia and CASE in the UK, followed by reference to research by Georgiades (2001) in Cyprus. Keeping in mind the development of researches on metacognition researcher decided to review the studies related to metacognition which is given below.

2.2 Review of Related Studies

The review of related studies led the investigator to classify it in the following categories.

- Review of researches based on development of metacognition
- Review of researches based on relation between metacognition and other variables
- Review of researches based on assessment of metacognition
- Review of researches based on effect of metacognition on different variables
- Review of researches based on effect of constructivist approach

Following each categories of research investigator has presented overview of the research related to that category in tabular and description form. Based on these overviews the implication for the present research has been drawn out.

2.2.1 Review of Researches Based on Development of Metacognition

Artzt & Armour-Thomas (1992) studied the Development of a Cognitive-Metacognitive Framework for Protocol Analysis of Mathematical Problem Solving in Small Groups. A framework is presented that explicitly delineates the roles of metacognition and cognition within small-group heuristic problem solving in mathematics. This framework is usec to describe the videotaped behaviors of 27 seventh-grade students of varying ability working in small groups to solve a mathematical problem. The results suggest the importance of metacognitive processes in mathematical problem solving in a small-group setting. A continuous interplay of cognitive and metacognitive behaviors appears to be necessary for successful problem solving and maximum student involvement. Within the groups, students returned several times to such problem-solving episodes as reading, understanding, exploring, analyzing, planning, implementing, and verifying. Stimulated-recall interviews held after completion of the task underscored an additional dimension of importance. Attitudes, particularly those of high-ability students, seemed to affect the interactions
and the problem-solving behaviors of fellow group members. The framework shows promise of being a powerful tool for the future study of mathematical problem solving in a small-group setting.

Goos & Galbraith (1996) studied the metacognitive strategies in collaborative mathematical problem solving. The study investigated the monitoring behaviour of a pair of senior secondary school students as they worked collaboratively on problems in applied mathematics. Analysis of verbal protocols from think aloud problem solving sessions showed that, although the students generally benefited from adopting complementary metacognitive roles, unhelpful social interactions sometimes impeded progress. The findings shed some light on the nature of individual and interactive metacognitive strategy use during collaborative activity.

Arzt & Armour-Thomas (1998) studied mathematics teaching as problem solving: A framework for studying teacher metacognition underlying instructional practice in mathematics. The purpose of this exploratory study was to use a “teaching as problem solving” perspective to examine the components of metacognition underlying the instructional practice of seven experienced and seven beginning teachers of secondary school mathematics. A metacognitive framework was developed to examine the thoughts of teachers before, during and after lesson enactments. Data were obtained through observations, lesson plans, videotapes, and audiotapecs of structured interviews during the course of one semester. Data analysis suggests that the metacognition of teachers plays a well-defined role in classroom practice. These findings provide useful insights for researchers and teacher educators in their pre-service and in-service mathematics programs.

Stillman & Galbraith (1998) studied the problem applying mathematics with real world connections: metacognitive characteristics of secondary students. This is an intensive study of problem-solving activity of female students at the senior secondary level. The study focused both on the mathematical processing and the underlying cognitive and metacognitive activities that led to that processing. Response maps were used to analyze and categorize the written responses from individual students while videotaped problem solving sessions and structured and free response interviews probed the students' metacognitive knowledge, strategies, decision making, beliefs and affects. Metacognitive activities were involved in all phases of the solution process with key points in students' solutions identifiable in terms of the cognitive-metacognitive framework of (Garofalo and Lester, 1985). On average more time was
spent on orientation and execution activities with little time being spent on organisation and verification activities, however, the successful groups spent less time on orientation than the other groups. All successful groups displayed a high number of key points where metacognitive decisions could influence cognitive action. Success was accompanied by a tendency to engage in a high number of organisational activities, regulation of execution activities and evaluation activities particularly evaluation of execution but fewer opportunities where metacognitive decisions could influence cognitive actions during orientation.

Brownlee, Purdie & Boulton-Lewis (2003) studied an investigation of student teachers’ knowledge about their own learning. Twenty-nine student teachers from a large metropolitan university in Queensland, Australia were interviewed at the beginning (Time 1) and end (Time 2) of a year-long graduate diploma in education to investigate the nature of their knowledge about learning and changes in such knowledge over the year. At Time 1 and Time 2 most students thought learning should be meaningful and preferred to use transformative learning approaches. However, students indicated a willingness to engage in reproductive approaches to learning if the content to be learned was uninteresting, workloads were high, or assessment was examination-focused. The results also indicated that while many students did not experience significant changes in their knowledge about learning over the year, they believed that transformative learning had become more of a focus for them. Investigating student teachers’ knowledge about learning has implications for effective learning in teacher education programs.

Davidowitz & Rollnick (2003) investigated the enabling Metacognition in the Laboratory: A Case Study of Four Second Year University Chemistry Students. This paper explores the Competency Tripod model and flow diagrams as two resources for enabling students’ metacognition in the chemistry laboratory. It focuses on four selected students’ statements in interviews, questionnaires and their performance in practical reports, examinations and tests. These students were from diverse backgrounds and all were successful in the sense that they passed the course. All four students were found to engage in metacognitive practices, all found flow diagrams extremely useful, all understood the Competency Tripod model but only two found it useful.

Jacobs (2004) studied a classroom investigation of the growth of metacognitive awareness in kindergarten children through the writing process. This
study investigated the presence and growth of kindergarten children’s metacognition as they engaged in the writing process. The study was conducted in an environment that surrounded children with books, language, and print. Twice a month the teacher/researcher interviewed the children as they finished writing, asking questions designed to help them reflect on their thinking and strategies they used in their writing. Anecdotal records, observations, and individual writing folders were used to complete a checklist of writing strategies for each child. Interviews with the children confirmed that they were exhibiting and showing growth in their metacognition. They were able to provide appropriate answers to questions that required them to talk about their thinking and identify strategies that helped them in their writing. The study provides a model that could be used in classrooms to help children in the development of their growing metacognition and writing in an authentic learning environment.

Vukman (2005) studied the developmental differences in metacognition and their connections with cognitive development in adulthood. This study investigated developmental differences in some metacognitive variables in ill-defined problem solving and their possible connections with cognitive development in adulthood. Participants were 57 individuals of different ages (adolescents, young adults, mature adults, and older adults). They solved one well-defined and six ill-defined problems while their thinking aloud was taped. They then answered a metacognitive statements questionnaire. Differences in performance were statistically significant in all problems: the best results in interpolation and divergent production problems were achieved by the younger adult group and the best performance on most dialectical everyday problems was found in the mature adults’ group. He found no significant differences between age groups in the online monitoring of the solving process. Accuracy in metacognitive statements was however significantly better in the mature adult and the younger adult groups. Awareness of and reflection on one’s own mental processes showed a similar developmental pattern to relativistic/dialectical thought: low expression in adolescence, an increase in early adulthood, a peak in mature adulthood, and a minor decline in later years.

Annevirta & Vauras (2006) studied the developmental changes of metacognitive skill in elementary school children. The authors investigated the development of metacognitive skill (MS) of 43 children from preschool to the 2nd grade (6–8 years of age) in a problem-solving situation. The children’s skill to direct, guide, and monitor their performance in a play-like problem-solving context was
evaluated in 3 experimental groups of preschool children with high, average, or low metacognitive knowledge (MK). The development of MS was further compared with the development of general MK of the same children. The results showed that children with initially high MK had better MS in problem-solving tasks during the 1st 2 school years, whereas the self-guided behavior of children with lower MK resembled more the type of adult-dependent behavior typical of young children as late as the 2nd grade. However, there was no clear developmental relationship between MK and MS.

Case & Gunstone (2006) studied the metacognitive development: A view beyond cognition. A series of studies were conducted to investigate students’ metacognitive development in a second year chemical engineering course. The first of these was an exploratory study involving observation together with some limited interviewing. This was followed by a major study with two phases, the first of which involved a series of individual interviews with eleven students over the duration of the course, and the second of which involved a follow-up interview with each student two years later. In the first phase of the major study a theoretical framework characterising metacognitive development as a shift in approach to learning was utilized. The present paper draws on the findings of the second phase of the major study to both confirm the validity of this framework and also point to some of its shortcomings, specifically regarding the necessity of a certain emotional state in order for metacognitive development to take place, and the importance of the formation of a professional identity. It is suggested that metacognitive development needs to be characterised in broader terms than the usual cognitive focus in order to more fully account for students’ experiences of learning.

Hurme, Palonen & Ja¨rvelä¨ (2006) studied the metacognition in joint discussions: an analysis of the patterns of interaction and the metacognitive content of the networked discussions in mathematics. The aim of this study was to examine metacognition in computer supported collaborative problem solving. The subjects of the study were 13-yearold Finnish secondary school students (N = 16). The Knowledge Forum learning environment was used to support student pairs’ problem-solving task involving polygons in a geometry course. The data consist of the student pairs’ posted computer notes (n = 95). To examine metacognition in a social context in the networked discussions, the features and patterns of networked interaction, the metacognitive content of the computer notes and their relations were examined. To
examine the features of networked interaction, the social network analysis measures were used. The patterns of networked interaction were displayed with the multidimensional scaling technique. In the analysis, metacognitive contents of the computer notes were categorized as metacognitive knowledge, metacognitive skills, and not metacognitive. Further, with the correspondence analysis, we examined how the student pairs’ metacognitive activity was distributed. The results of the study revealed that the metacognitive activity varied among participants, although some aspects of metacognition such as planning were never encountered. It was found that there is a relation between metacognitive activity and the features of interaction. The student pairs who monitored and evaluated the ongoing discussions had a strategically optimal position in the communication network.

*Kung & Linder (2007)* studied the metacognitive activity in the physics student laboratory: is increased metacognition necessarily better? In this study natural-in-action metacognitive activity during the student laboratory in university physics is explored, with an aim towards quantifying the amount of metacognition used by the students. The study investigates whether quantifying natural inaction metacognition is possible and valuable for examining teaching and learning in these contexts. Video recordings of student groups working during three types of introductory physics laboratories were transcribed and then coded using a coding scheme developed from related research on mathematical problem solving. This scheme identifies a group’s general behaviour and metacognitive activity. The study recognizes that reliably identifying metacognition is challenging, and steps are taken to improve reliability. Results suggest that a greater amount of metacognition does not appear to improve students’ success in the laboratory—what appears to matter is whether the metacognition causes students to change behaviour. This study indicates that it is important to consider the outcome of metacognition, not just the amount.

*Annevirta, Laakkonen, Kinnunen & Vauras (2007)* studied the developmental dynamics of metacognitive knowledge and text comprehension skill in the first primary school years. The aim of this study was, firstly, to explore the development of primary school children’s metacognitive knowledge from preschool to the 2nd grade and the development of their text comprehension skill from the 1st grade to the 3rd grade. Secondly, the developmental dynamics between metacognitive knowledge (MK) and text comprehension skill (CS) across the first three school years were investigated. The longitudinal sample included 181 children who were tested three
times from preschool spring to the spring term of the 3rd grade using an identical set of measurements: the Metacognitive Knowledge Test and Listening and Reading Comprehension Tests. In studying developmental change using Latent Growth Curve modeling (LGC), no uni-construct effect for the development of MK or for text CS was found. However, a slight multi-construct cumulative development between the children’s MK and reading CS was identified. Thus, it could be cautiously interpreted that the more the children’s MK developed from preschool to the end of the 2nd grade, the better reading CS they showed during the first three school years.

*Kipnis & Hofstein (2008)* studied the inquiry laboratory as a source for development of metacognitive skills. The study is based on a long-term comprehensive series of investigations that were conducted in the context of teaching high school chemistry in the laboratory using inquiry-type experiments. The students that study chemistry according to this program are involved in an inquiry process that included all the inquiry skills namely: identifying problems, formulating hypotheses, designing an experiment, gathering and analyzing data, and drawing conclusions about scientific problems and phenomena. While conducting these activities in small collaborative groups, they were encouraged to discuss their ideas about the scientific phenomena they were observing with their classmates and they were provided the time needed to accomplish it. A case study of inquiry activity of a group of three students is described and analyzed using a model of metacognition that was presented by Schraw (1998). The transcripts of the interviews of 20 students were analyzed using a model of Flavell et al. (2002). It was found that while performing the inquiry activity, the students practiced their metacognitive abilities in various stages of the inquiry process. The analysis of the interviews indicated that the students that participated in the research expressed their metacognitive knowledge regarding the inquiry activity. Thus, it is claimed that an inquiry-type laboratory that is properly planned and performed can give students an opportunity to practice metacognitive skills, which are regarded in recent years as one of the key goals in our attempt to broaden the scope of learning skills developed through learning science.

*Ritchhart, Turner & Hadar (2009)* investigated uncovering students’ thinking about thinking using concept maps. A method for uncovering students’ thinking about thinking, specifically their meta-strategic knowledge, is explored within the context of an ongoing, multi-year intervention designed to promote the development of students’ thinking dispositions. The development of a concept-map instrument that classroom
teachers can use and an analytic framework for interpreting students’ responses is presented. In a preliminary study, the concept map instrument is piloted to evaluate changes in students’ conceptions of thinking after a year’s participation in classrooms where their teachers actively sought to make thinking more visible by noticing and naming the thinking observed as well as introducing and using thinking routines. Concept maps from 239 students from grades 3 through 11 were analyzed. Results suggest that students’ conceptions of thinking do improve with age but also can be substantially developed through a classroom culture where thinking is modeled and rich opportunities for thinking are present. The concept map instrument itself proved to be a robust instrument for uncovering students’ thinking about thinking.

Leutwyler (2009) studied on metacognitive learning strategies: differential development patterns in high school. The main objective of this study is to identify the development of students’ self-reported use of metacognitive learning strategies during high school. Therefore, the study analyses the differential development patterns of 1,432 students, between grade 10 and 12, in a longitudinal sample. The results suggest that, from a global perspective, there is no development of students’ self-reported use of metacognitive learning strategies during high school. The expected gender-specific differences in favour of female students are replicated in this sample. However, the self-reported use of monitoring and evaluation strategies tends to converge between genders during high school, whereas the differences in the self-reported use of planning strategies remain stable.

Dutke, Barenberg & Leopold (2010) studied the learning from text: knowing the test format enhanced metacognitive monitoring. In an experiment with 56 young adults, the hypothesis was tested that information about the format of an anticipated test improves metacognitive monitoring. Half of the participants were informed about the format of the test before they started studying a text about human genetics. The other half of the sample received the same information after studying the text. All participants then answered 15 true-false inference items about the contents of the text and judged their confidence in the correctness of each answer. Whereas experimental and control group did not differ in the number of correct answers, the confidence judgments in the experimental group were more accurate and discriminated better between correct and incorrect answers than the control participants’ judgments. Furthermore, the informed participants’ discrimination performance correlated
positively with their domain-related prior knowledge. The results extend earlier findings concerning the role of the test format for monitoring processes.

### 2.2.2 Overview of Researches based on Development of Metacognition

Table 2.1

<table>
<thead>
<tr>
<th>No.</th>
<th>Name &amp; Year</th>
<th>Situation</th>
<th>Method &amp; Sample</th>
<th>Tools</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Artzt &amp; Armour-Thomas (1992)</td>
<td>Problem solving situation</td>
<td>Exploratory 27 seventh grade</td>
<td>Video-tape &amp; Stimulated recall Interview</td>
<td>Qualitative</td>
</tr>
<tr>
<td>2</td>
<td>Goos &amp; Galbraith (1996)</td>
<td>Problem solving situation</td>
<td>Case study 20 pair of senior secondary school</td>
<td>Videotape</td>
<td>Qualitative</td>
</tr>
<tr>
<td>3</td>
<td>Artzt &amp; Armour-Thomas (1998)</td>
<td>Problem solving situation</td>
<td>Exploratory 7 experience &amp; 7 beginners teachers</td>
<td>Observation, Lesson plans, Videotape &amp; audiotape</td>
<td>Qualitative</td>
</tr>
<tr>
<td>4</td>
<td>Stillman &amp; Galbraith (1998)</td>
<td>Problem solving situation</td>
<td>Case study 15 senior secondary school</td>
<td>ResponseMaps, Videotape, structured and free response Interview</td>
<td>Qualitative</td>
</tr>
<tr>
<td>5</td>
<td>Brownlee, Purdie &amp; Boulton-Lewis (2003)</td>
<td>Teacher training course</td>
<td>Case study 29 student-teachers</td>
<td>Interview</td>
<td>Quantitative</td>
</tr>
<tr>
<td>6</td>
<td>Davidovitz &amp; Rollnick (2003)</td>
<td>Laboratory condition</td>
<td>Case study 4 second year uni. Chemistry students</td>
<td>Interview, Questionnaire, Practical report, tests</td>
<td>Qualitative</td>
</tr>
<tr>
<td></td>
<td>Authors (Year)</td>
<td>Method</td>
<td>Sample</td>
<td>Design</td>
<td>Data Collection</td>
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<tr>
<td>7</td>
<td>Jacobs (2004)</td>
<td>Writing process</td>
<td>Case study 16 Kindergarten children</td>
<td>Interview, Anecdotal Records, Observations and Individual writing folder</td>
<td>Qualitative</td>
</tr>
<tr>
<td>8</td>
<td>Vukman (2005)</td>
<td>Problem solving situation</td>
<td>Experimental 57 individuals</td>
<td>Questionnaire</td>
<td>Qualitative</td>
</tr>
<tr>
<td>9</td>
<td>Annevirta &amp; Vauras (2006)</td>
<td>Problem solving situation</td>
<td>Experimental 43 Pre-schooler</td>
<td>MKT &amp; MST</td>
<td>Correlation</td>
</tr>
<tr>
<td>10</td>
<td>Case &amp; Gunstone (2006)</td>
<td>Laboratory condition</td>
<td>Exploratory 11 second year Chemical Engineering student</td>
<td>Interview</td>
<td>Qualitative</td>
</tr>
<tr>
<td>11</td>
<td>Hurme, Palomen &amp; Ja verla (2006)</td>
<td>Problem solving situation</td>
<td>Qualitative 95 secondary school student</td>
<td>Multidimensional Scaling Technique</td>
<td>Qualitative</td>
</tr>
<tr>
<td>12</td>
<td>Annevirta, Laakkonen, Kinnunen &amp; Vauras (2007)</td>
<td>First primary school years</td>
<td>Longitudinal 181 primary students</td>
<td>MCK</td>
<td>Quantitative</td>
</tr>
<tr>
<td>13</td>
<td>Kung &amp; Linder (2007)</td>
<td>Laboratory condition</td>
<td>Exploratory 15 Physics seniorsecondary school student</td>
<td>videotape</td>
<td>Qualitative</td>
</tr>
<tr>
<td>14</td>
<td>Kipnis &amp; Hofstein (2008)</td>
<td>Laboratory condition</td>
<td>Case study 20 high school chemistry students</td>
<td>Videotape, Interview, Reflective Journal</td>
<td>Qualitative</td>
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</table>
Researcher reviewed seventeen studies based on the development of metacognition. Out of seventeen studies seven were based on development of metacognition in mathematical problem solving situation, four were based on development of metacognition in chemistry and physics laboratory condition, four were based on development of metacognition during writing process, learning from text, using concept maps and during teacher training course respectively while two were based on development of metacognition in natural condition.

Out of seventeen studies three studies were conducted using experimental method, five through exploratory method, seven through case study and two through longitudinal method.

During three experimental studies sample selected were ranged from 43 to 57 individuals. During exploratory studies sample selected were ranged from 11 to 239 individuals. During case studies sample selected were ranged from 4 to 29 individuals. During longitudinal studies sample selected were ranged from 181 to 1432 individuals. Out of seventeen studies two studies were included kindergarten children, two studies were included primary school children, seven studies were included secondary and senior secondary school children, two studies were included student-
teachers, two studies were included university students, two studies were included adults.

Regarding tools for the study two researchers used MK test while one used MST. Six researchers had used video tape as a tool for data collection. Seven researchers had used interview as a tool for data collection while three had used questionnaire. Two researcher had used observation, while lesson plan, audio-tape, response maps, multidimensional scaling technique, practical report, student reflective journal, anecdotal records, individual writing folder, concept map and self report was used by one each as a tools for the data collection. Thus varieties of tools were used by researchers in combination or in single.

Regarding analysis of data thirteen researcher had analyzed their data using qualitative techniques while four researchers had used quantitative techniques. Since most of researcher had used exploratory and case study method and observation and interview tools for data collection they used qualitative analysis as the data obtained were mostly qualitative in nature.

Important findings related to these researches were no developmental relation was found between MK and MS (Annevira & Vauras, 2006). According to Artzt & Armour-Thomas (1992) there is importance of metacognitive processes in mathematical problem solving in a small group setting. Artzt & Armour-Thomas (1998) suggest that metacognition of teachers plays a well-defined role in classroom practice. Vukman (2005) finds that accuracy in metacognitive statements was significantly better in the mature adult and the younger adult groups. Stillman & Galbraith (1998) finds that metacognitive activities were involved in all phases of the problem solution process. Goos & Galbraith (1996) finds that the students generally benefited from adopting complementary metacognitive roles, unhelpful social interaction sometimes impeded progress. Hurme, Palomen & Ja verla (2006) found that there is a relation between metacognitive activity and the features of interaction.

Case & Gunstone (2006) suggested that metacognitive development needs to be characterised in broader terms than the usual cognitive focus in order to more fully account for students’ experiences of learning. Kung & Linder (2007) found that greater amount of metacognition does not appear student’s success in the laboratory. Davidovitz & Rollnick (2003) found that all students were engage in metacognitive practices during their laboratory work. Kipnis & Hofstein (2008) found that while
performing the inquiry activity, the students practiced their metacognitive abilities in various stages of the inquiry process.

Jacobs (2004) found that children showing growth in their metacognition during writing process. Dutke, Barenberg & Leopold (2010) found that the confidence judgements in the experimental group were more accurate and discriminated better between correct and incorrect answers than the control participant’s judgements.

Ritchhart, Turner & Hadar (2009) found that concept map instrument proved to be a robust instrument for uncovering students thinking about thinking. Brownlee, Purdie & Boulton-Lewis (2003) found that students did not experience significant changes in their knowledge about learning. Leutwyler (2009) found that there is no development of student’s self-reported use of metacognitive learning strategies during high school. Annevirta, Laakkonen, Kinnunen & Vauras (2007) found no uni-construct effect for the development of MK or for text CS.

2.2.3 Review of Researches Based on Relation between Metacognition and other Variables

Sperling, Howard, Staley & DuBois (2004) studied the metacognition and self-regulated learning constructs. The chief objectives were to study the correlations among metacognitive constructs and between measures of metacognition, second to further address learning strategy use and metacognition, third to examine metacognition and achievement and fourth to examine relationships between measures of metacognition and motivational variables. Two separate study was conducted to achieve the above-mentioned objectives, study 1 addressed first three goals and study 2 addressed fourth goals. Study 1 involves 109 participants primarily 1st year students enrolled in an academic strategies class at a northeastern college. The sample in study 1 represented a cross section of student majors while in study 2 participants were enrolled in an educational psychology course and were generally sophomore and junior education majors. For study 1 tools used were Metacognitive Awareness Inventory (MAI) (Schraw & Dennison, 1994) and the learning strategies survey (LSS) (Kardas & Amlund, 1991). The MAI was comprised of fifty-two 5-point Likert-scale items that were divided into two scales. First, the knowledge of cognition scale measures an awareness of one’s strengths and weakness, knowledge about strategies and why and when to use those strategies. Second the regulation of cognition, measures knowledge about planning, implementing, monitoring and evaluating strategy use. The LSS was comprised of a 27-item, 5-point Likert-scale
inventory is also comprised of two scales. The 18-item Covert Cognitive Processes scale measures internal information processing, organization and elaboration, the second comprise the 9-item Overt Processes scale measures observable encoding strategies. For study 2 tools used were MAI, Motivated Strategies Learning Questionnaire (MSLQ) (Garcia & Pintrich, 1995), and confidence judgements of test taking. The MSLQ is comprised of two main sections: learning strategies and motivation. Learning strategies include four scales Rehearsal, elaboration, organization, and critical thinking. The strategies section also includes metacognitive regulation scale that consists of 12 items that address the use of strategies to control learning. Four resource management scales also included. This includes time and study environmental management, peer learning, effort regulation and help-seeking.

The motivation section includes three scales: intrinsic goal orientation, extrinsic goal orientation and task value. It also includes two expectancy scales: control of learning beliefs and self efficacy for learning and performance. The last scale in the motivation section is an affect scale: test anxiety. Three measures of confidence judgments of test taking were calculated across two 20-item objective tests. Major findings of this study were knowledge and regulation components of metacognition were strongly related with each other. In study 1, significant negative relationships between academic management and metacognition were indicated. In study 2, positive significant correlation two self report measures of metacognition the MAI and MSLQ. Little support for relationships between self report measures of metacognitive processing and accuracy of confidence judgments was indicated. Two of six accuracy judgments were correlated with one of the MAI components: one was a significant inverse relationship, contrary to hypothesis. Across both studies, findings illustrated positive and significant correlations between metacognition and strategy use measures. The relationship between metacognition and achievement was not predicted to be strong. Findings suggested less robust correlations between metacognition and motivation than for metacognition and strategy use.

Desoete, Roeyers & Huylebroeck (2006) studied the metacognitive skills in Belgian third grade children (age 8 to 9) with and without mathematical learning disabilities. This paper presents a study on mathematical problem solving in third grade pupils. The relationship between mathematics, metacognition and intelligence was investigated in children with (n = 191) and without mathematical learning disabilities (n = 268). A significant relationship was found between prediction,
evaluation, intelligence, procedural and mathematical fact retrieval skills in children without mathematical learning disabilities. In the children with mathematical learning disabilities a relationship was found between metacognitive and procedural skills. No such relationship was found between intelligence and metacognition or between metacognition and mathematical fact retrieval skills. In addition it was investigated if children with mathematical learning disabilities had less adequate metacognitive skills than peers without learning problems. At group level significant differences were found between both groups. However on analyzing these results further, it was found that four out of five children with combined mathematical learning disabilities, half of the children with procedural disabilities and only 5% of the children with a retrieval deficiency had low metacognitive skills. Furthermore, metacognitive problems were found in one out of five children without learning disabilities. Moreover, a majority of the children with mathematical learning disabilities and inadequate metacognitive skills had problems with prediction and evaluation skills. Most third graders with low metacognitive skills only appeared to have problems predicting the level of difficulty of tasks. Inaccurate evaluations were found on a more regular basis in children with mathematical learning disabilities and inadequate metacognitive skills as opposed to the sample of children with inadequate metacognitive skills but without learning difficulties, where their occurrence was rather a one off.

Yilmaz-Tuzun, Topcu (2010) Investigated the Relationships among Elementary School Students’ Epistemological Beliefs, Metacognition, and Constructivist Science Learning Environment. The research questions addressed in this study were: what types of epistemological beliefs do elementary students have; what types of metacognition do elementary students have; and what are the relationships among students’ perceived characteristics of constructivist learning environment, metacognition, and epistemological beliefs. A total of 626 students enrolled in sixth, seventh, and eight grades of nine elementary public schools located in Ankara, Turkey constituted the participants of this study. Constructivist learning environment scale (CLES), Junior Metacognitive Awareness Inventory (Jr. MAI), and Schommer epistemological belief questionnaire (SEBQ) were administered to students. Factor Analysis of Jr. MAI revealed both knowledge of cognition and regulation of cognition items were loaded into one factor. Confirmatory factor analysis of SEBQ revealed a four factor structure namely innate ability, quick learning, omniscient authority, and certain knowledge. Regression analyses revealed that metacognition and omniscient
authority were significant predictors of personal relevance dimension of CLES. Metacognition was found as the only predictor of the student negotiation. Innate ability and metacognition significantly contributed to uncertainty. This study revealed that the elementary students with different mastery levels hold different epistemological beliefs and multi-faceted nature of elementary school students’ metacognition was seemed to be supported with this study. It was found that metacognition contributed to model more than epistemological beliefs for all three dimensions of CLES.

2.2.4 Overview of Researches based on relation between metacognition and other variables

<table>
<thead>
<tr>
<th>No</th>
<th>Name &amp; Year</th>
<th>Relation</th>
<th>Method &amp; Sample</th>
<th>Tools</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sperling &amp; Dubois (2004)</td>
<td>metacognitive constructs &amp; measures of metacognition, learning strategy use &amp; metacognition, third metacognition &amp; achievement and fourth measures of metacognition &amp; motivational variables</td>
<td>Correlation 109 1st year students</td>
<td>MAI, Learning Strategy Scale (LSS)</td>
<td>Correlation</td>
</tr>
<tr>
<td>2</td>
<td>Desoete, Roeyers &amp; Huylebroeck (2006)</td>
<td>relationship between mathematics, metacognition and intelligence</td>
<td>Correlation 191 with and 268 without learning disable 3rd grader</td>
<td>MST</td>
<td>Correlation and ANOVA</td>
</tr>
<tr>
<td>3</td>
<td>Yilmaz-Tuzun &amp; Topcu (2010)</td>
<td>Epistemological Beliefs, Metacognition, and Constructivist Science Learning Environment</td>
<td>Correlation 626 sixth, seventh and eighth grader</td>
<td>Jr. MAI, SEBQ, CLES</td>
<td>Correlation on, regression analysis</td>
</tr>
</tbody>
</table>
Researcher reviewed three researches related to relationship between metacognition and other psychological construct like learning strategy use, achievement, motivational variables, epistemological belief, constructivist science learning environment, mathematics and intelligence. All three studies were conducted using correlation method. Sample for these studies were ranged from 109 to 626. Participants were primary student in two studies and college student in another study. Tools used for data collection were MAI, Learning Strategy Scale (LSS). Jr. MAI, SEBQ, CLES, and MST. All three studies used correlation analysis for the interpretation of data.

Sperling & Dubois (2004) found positive significant relation between MA & Motivated Strategies Learning, between metacognition and strategy use while not strong relation between metacognition and achievement. Yilmaz-Tuzun & Topcu (2010) found that metacognition was the only predictor of the student negotiation. Desoete, Roeyers & Huylebroeck (2006) found a relationship between metacognitive and procedural skills. While no such relation between intelligence and metacognition or between metacognition and mathematical fact retrieval skills.

2.2.5 Review of Researches Based on Assessment of Metacognition

Staats, Dean, Miles, Blum, Ssu-yu Lu (2003) studied for developing techniques for measuring and enhancing students’ cognitive and metacognitive skills. The current pilot project seeks to develop a behavioral task measure of metacognition and to use exercises modeled on this behavioral task to teach and enhance metacognitive skills. These exercises, based on work by Deanna Kuhn at Columbia University, are to be incorporated in an undergraduate computer science program for the purpose of enhancing cognitive and metacognitive skills that have been identified as important for computer scientists.

First, the pilot study established a baseline comparison between the Metacognitive skills Inventory (MSI) and one of Kuhn’s most widely used causal inference tasks, dubbed the “boat-races” (BOATS) task. Second, the pilot study established a baseline comparison between the BOATS model task and several domain-specific tasks developed by the researchers; these domain specific tasked were modeled after the ones developed by Kuhn. Twenty-four participants in the computer science operating systems course and fifteen participants from the Research Methods in Psychology class completed all phases of the study. An independent samples t test was conducted to compare scores of the two groups on the boat exercise. There was a significant
difference, with \( t(37) = 3.54, p < .01 \), with the mean number of correct inferences higher for Computer Science students, \( (M=13.38 \) compared to \( M=9.13 \) for psychology students). Regression analyses were performed, using the BOATS (domain independent) task, the MSI scores, and the Metacognitive computer skill scale scores as predictor variables and performance on the newly created domain-specific tasks as criterion variables. While none of the individual component variables was found to be predictive of exercise task performance, the overall model was significant for at least two of the three domain-specific tasks. Continued research will use these task scores as predictors and Computer Science task performance as criterion variables. Should the exercises prove predictive, they will be used as training tools to develop metacognitive skill.

McKeown & Gentilucci (2007) studied the Think-Aloud strategy: Metacognitive development and monitoring comprehension in the middle school second-language classroom. This study examined how the Think-Aloud Strategy affects content area reading comprehension of middle school English learners by attempting to answer the question: will middle school English learners who employ the think aloud reading strategy demonstrate greater content area comprehension as measured by the High Point Selection Comprehension Assessment than those who do not employ the strategy? Twenty-seven English learners with a reading proficiency level of Early Intermediate (Level 2) or higher were included in the study. Five Early Intermediate students (Level 2), 11 Intermediate students (Level 3), and 11 Early Advanced students (Level 4) were included in the sample. A pretest and posttest of related samples were used to test the hypothesis that there would be a statistically significant positive difference between mean scores of pre- and posttests of the sample groups, signifying that the use of the Think-Aloud Strategy is an effective intervention for improving reading comprehension among the English-learner population. During the third and fourth week of the study, students began applying the Think-Aloud Strategy to their daily reading assignments in social studies, or they used an Accelerated Reader novel to practice strategic application of the strategy. Regina monitored students as they read aloud, prompting them to respond aloud about “what was going on in their heads” and encouraged them to think aloud in whatever language was more comfortable. Use of the Think-Aloud Strategy did not yield homogeneous results across the English-learner subgroups (i.e., Level 2, Level 3, and Level 4), the results show that use of the Think-Aloud Strategy did not help improve
the English learners’ comprehension of expository text; individual scores were nearly identical on pre- and posttests (see Figure 1). Although the difference in pre- and posttest means was not statistically significant, the data suggest measurable growth in students’ reading comprehension between pre- and posttests (Level 3). The findings suggest that while English learners successfully use metacognitive strategies such as think-aloud, the efficacy of the strategies depends on the unique needs of each particular level of proficiency as they approach the text. The findings of this study suggest that, like their Early Intermediate peers, Intermediate students initially become stuck at the word level; however, their knowledge of vocabulary and decoding ability (fluency) has progressed enough in their second language and their linguistic threshold is high enough to allow them to become top-down readers with proper modeling and practice of the strategy.

Bannert & Mengelkamp (2008) studied the assessment of metacognitive skills by means of instruction to think aloud and reflect when prompted. Does the verbalization method affect learning? Recent research on metacognition points out the crucial role of on-line methods when endeavouring to conduct valid assessments of metacognitive skills. Presently, different on-line methods are used, however, it is still a question of research whether and how they affect students’ learning behaviour and learning outcome. Thus, the aim of this study was to quasi-experimentally analyze the effects of two on-line verbalization methods on learning performance. By means of the thinking-aloud method, students in one experimental group (n=24) were instructed to read and think aloud during learning. With the reflection when prompted method, students of another experimental group (n=24) were prompted at each navigational step to reflect on the reasons why they chose specific information. Students in the control group (n=22) learned without being instructed to verbalize. All three groups were treated identically except for the different use of verbalization assessment methods. The students’ task was to learn the concepts and principles of operant conditioning presented in a hyper medium within 30 min. The students’ learning sessions were videotaped and learning performance was obtained immediately afterwards. Based on Ericsson and Simon’s (Protocol analysis: Verbal reports as data, MIT, Cambridge, 1993) model, no performance differences between the thinking aloud and the control group were hypothesized. However, prompting students for metacognitive reflection should affect learning performance positively, which is confirmed by the results only in tendency for transfer performance.
Desoete (2008) studied the multi-method assessment of metacognitive skills in elementary school children: how you test is what you get. Third grade elementary school children solved tests on mathematical reasoning and numerical facility. Metacognitive skillfulness was assessed through think aloud protocols, prospective and retrospective child ratings, teacher questionnaires, calibration measures and EPA2000. In our dataset metacognition has a lot in common with intelligence, but planning measured with teacher ratings plays a role above and beyond IQ. Moreover, we found that skills are generally related, but that it is more appropriate to assess them separately. In addition, results show the value of an experienced teacher as actual measure of metacognitive planning skills. Our dataset suggests convergent validity for prospective and retrospective child ratings, but no significant relationship with the other metacognitive measures. Metacognitive skillfulness combined with intelligence accounts for between 52.9% and 76.5% of the mathematics performances. The choice of diagnostic instruments highly determines the predicted percentage.

Thomas, Anderson & Nashon (2008) studied the Development of an Instrument Designed to Investigate Elements of Science Students’ Metacognition, Self-Efficacy and Learning Processes: The SEMLI-S. The development and evaluation of science students’ metacognition, learning processes and self efficacy are important for improving science education. This paper reports on the development of an empirical self-report instrument for providing a measure of students’ metacognition, self efficacy and constructivist science learning processes. A review of the range of literature related to metacognition, self-regulation and constructivist learning processes resulted in the development of an initial bilingual (English and traditional Chinese) instrument composed of 72 items. This instrument was completed by 465 Hong Kong high school students. The data collected were subjected to exploratory factor analysis and Rasch analysis. The subsequent refinement process resulted in a final version of the Self-Efficacy and Metacognition Learning Inventory—Science (SEMLI-S) consisting of 30 items that can be used for either analyzing and focusing on any or all of its dimensions or for assigning scores to individuals that enable comparison between them in relation to their metacognitive science learning orientations.

Shamir, Mevarech & Gida (2009) studied the assessment of meta-cognition in different contexts: individualized vs. peer assisted learning. This study investigated the effectiveness of assessing young children’s metacognition in different contexts
(i.e., individual learning (IL), peer assisted learning (PAL) and self-reports). Additionally, the contributions of declarative and procedural metacognition in IL and PAL, TOM and language ability on children’s cognitive performance (recalling a series of pictures) were examined. Sixty-four 4–5-year-old children (M=5.14; SD=0.72), randomly selected from two Israeli kindergartens, participated in the study. Children were first asked in an individualized setting to recall a series of nine pictures: they were then asked (self-report) to tell the interviewer how they tried to recall the pictures.

Finally, they were asked to assist a peer in recalling the pictures in a PAL situation. All the children’s verbal and non-verbal behaviors were coded and analyzed. In addition, the children’s language ability and Theory of Mind (TOM) were assessed. The findings indicated significant differences between children’s declarative (self-report) and procedural meta-cognitive behavior in IL and PAL. Procedural meta-cognition in PAL and TOM predicted cognitive performance even when procedural meta-cognition in IL, declarative meta-cognition and language ability were controlled for.

Whitebread, et al. (2009) studied the development of two observational tools for assessing metacognition and self-regulated learning in young children. This paper reports on observational approaches developed within a UK study to the identification and assessment of metacognition and self-regulation in young children in the 3–5 year age range. It is argued that the development of observational tools, although containing methodological difficulties, allows us to make more valid assessments of children’s metacognitive and self-regulatory abilities in this age group. The analysis of 582 metacognitive or self-regulatory videotaped ‘events’ is described, including the development of a coding framework identifying verbal and non-verbal indicators. The construction of an observational instrument, the Children’s Independent Learning Development (CHILD 3–5) checklist, is also reported together with evidence of the reliability with which it can be used by classroom teachers and early indications of its external validity as a measure of metacognition and self-regulation in young children. Given the educational significance of children’s development of metacognitive and self-regulatory skills, it is argued that the development of such an instrument is potentially highly beneficial. The establishment of the metacognitive and self-regulatory capabilities of young children by means of the kinds of observational tools
developed within this study also has clear and significant implications for models and theories of metacognition and self-regulation.

### 2.2.6 Overview of Researches based on Assessment of Metacognition

Table 2.3

Name & year, assessment, method & sample, tools and analysis of researches based on assessment of metacognition

<table>
<thead>
<tr>
<th>No.</th>
<th>Name &amp; Year</th>
<th>Assessment</th>
<th>Method &amp; Sample</th>
<th>Tools</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Staats, Dean Miles, Blum &amp; Ssu-yu Lu (2003)</td>
<td>BOATS model task</td>
<td>Experimental 39 university students</td>
<td>MSI &amp; Metacognitive Computer Skill Scale</td>
<td>t-test regression analysis</td>
</tr>
<tr>
<td>2</td>
<td>McKeown &amp; Gentilucci (2007)</td>
<td>Think Aloud strategy</td>
<td>Experimental 27 English learner</td>
<td>Test &amp; Observation</td>
<td>t-test</td>
</tr>
<tr>
<td>4</td>
<td>Desoete (2008)</td>
<td>think aloud protocols, child ratings, questionnaires, calibration measures and EPA2000</td>
<td>Exploratory Third grade elementary school children</td>
<td>think aloud protocols, child ratings, questionnaires, calibration measures and EPA2000</td>
<td>Qualitative</td>
</tr>
</tbody>
</table>
Researcher reviewed seven study related to assessment of metacognition. Out of seven studies three used think aloud protocol, two used self report instrument, one used BOATS model task, reflected when prompted, Observation & Children’s Independent Learning Development (CHILD 3–5) checklist, prospective and retrospective child ratings, teacher questionnaires, calibration measures and EPA2000 as a tools for the assessment of metacognition. Four researchers used experimental method, two used exploratory method and one used survey method to conduct the study. Sample used were ranged from 27 to 582. Five study included elementary school children, one high school and one university students as a sample of the study. Four studies used quantitative method, two used qualitative method and one used quantitative and qualitative method for analysis of the data.

Staats, Dean Miles, Blum & Ssu-yu Lu (2003) found that MSI scores and the metacognitive computer skill scale scores as predictor variables and performance on the newly created domain-specific task as criterion variable. Bannert & Mengelkamp (2008) found that prompting students for metacognitive reflection affect learning performance positively. McKeown & Gentilucci (2007) found that English learners successfully use metacognitive strategies such as think-aloud. The efficacy of the strategies depends on the unique needs of each particular level of proficiency. Thomas. Anderson & Nashon (2008) found that SEMLI-S can be used for either analyzing or focusing on any or all of its dimensions or for assigning scores to individuals that enable comparison between them in relation to their metacognitive science learning orientation. Shamir, Mevarech & Gida (2009) found significant differences between children’s declarative and procedural metacognitive behaviour in
IL and PAL. Whitebread & et al. (2009) found that development of (CHILD 3–5)
checklist is potentially highly beneficial. Desoete (2008) found that metacognition has
lot in common with intelligence but planning measured with teacher ratings plays a
role above and beyond IQ.

2.2.7 Review of Researches Based on Effect of Metacognition on
Different Variables

Kramarski, Mevarech & Arani (2002) studied the effects of metacognitive
instruction on solving mathematical authentic tasks. The study investigated the
differential effects of cooperative-learning with or without metacognitive instruction
on lower and higher achievers' solutions of mathematical authentic tasks. Participants
were 91 seventh graders who studied in three classrooms. Data were analyzed by
using qualitative and quantitative methods. Results indicated that students who were
exposed to the metacognitive instruction within cooperative learning (COOP+META)
significantly outperformed their counterparts who were exposed to cooperative
learning with no metacognitive instruction. The positive effects of COOP+META
were observed on both authentic and standard tasks. In addition, the findings show the
positive effects of COOP+META method on lower and higher achievers.

Kramarski & Mevarech (2003) studied the enhancing mathematical reasoning
in the classroom: the effects of cooperative learning and metacognitive training. The
purpose of this study was to investigate the effects of our instructional methods on
students' mathematical reasoning and metacognitive knowledge. The participants
were 384 eighth-grade students. The instructional methods were cooperative learning
combined with metacognitive training (COOP+META), individualized learning
combined with metacognitive training (IND+META), cooperative learning without
metacognitive training (COOP), and individualized learning without metacognitive
training (IND). Results showed that the COOP+META group significantly
outperformed the IND+META group, which in turn significantly outperformed the
COOP and IND groups on graph interpretation and various aspects of mathematical
explanations. Furthermore, the metacognitive groups (COOP+META and
IND+META) outperformed their counterparts (COOP and IND) on graph
construction (transfer tasks) and metacognitive knowledge.

Kramarski (2008) studied the Promoting teachers’ algebraic reasoning and
self-regulation with metacognitive guidance. This study investigates algebraic
reasoning and self-regulation skills among elementary school teachers who
participated in a professional development (PD) program either with IMPROVE metacognitive questioning (PD+Meta) or with no metacognitive guidance (PD). Sixty-four Israeli teachers participated in a 3-year program designed to enhance mathematical knowledge. Results indicated that the PD+Meta teachers outperformed the PD teachers on various algebraic procedural and real-life tasks regarding conceptual mathematical explanations. In addition, the PD+Meta group outperformed the PD group in using self-monitoring and evaluation strategies in algebraic problem solving.

*Mevarech & Amrany (2008)* studied the immediate and delayed effects of meta-cognitive instruction on regulation of cognition and mathematics achievement. The study addressed two research questions: (a) the extent to which students who were exposed to metacognitive instruction are able to implement metacognitive processes in a delayed, stressful situation, in this case—being examined on the matriculation exam; and (b) whether students preparing themselves for the matriculation exam in mathematics, attain a higher level of mathematics achievement and metacognitive awareness (knowledge about cognition and regulation of cognition) as a result of being exposed to metacognitive instruction. Participants were 61 Israeli high school students who studied mathematics for four-point credit on the matriculation exam (middle level). About half of the students (N=31) were assigned to meta-cognitive instruction, called IMPROVE, and the others (N=30) studied with no explicit meta-cognitive guidance (control group). Analyses included both quantitative and qualitative methods. The later was based on students’ interviews, conducted about a couple of months after the end of the intervention, immediately after students completed the matriculation exam in mathematics. Results indicated that IMPROVE students outperformed their counterparts on mathematics achievement and regulation of cognition, but not on knowledge about cognition. Furthermore, during the matriculation exam, IMPROVE students executed different kinds of cognitive regulation processes than the control students. The theoretical and practical implications of the study are discussed.

*Magno (2010)* studied the role of metacognitive skills in developing critical thinking. The study investigated the influence of metacognition on critical thinking skills. It is hypothesized in the study that critical thinking occurs when individuals use their underlying metacognitive skills and strategies that increase the probability of a desirable outcome. The Metacognitive Assessment Inventory (MAI) by Schraw and
Dennison (1994), which measures regulation of cognition and knowledge of cognition, and the Watson-Glaser Critical Thinking Appraisal (WGCTA) with the factors inference, recognition of assumptions, deduction, interpretations, and evaluation of arguments were administered to 240 college students from different universities in the National Capital Region in the Philippines. The Structural Equations Modeling (SEM) was used to determine the effect of metacognition on critical thinking as latent variables. Two models were tested: (1) In the first model, metacognition is composed of two factors while (2) in the second model; metacognition has eight factors as they affect critical thinking. The results indicated that in both models, metacognition has a significant path to critical thinking, p<.05. The analysis also showed that for both metacognition and critical thinking, all underlying factors are significant. The second model had a better goodness of fit as compared with the first as shown by the RMSEA value and other fit indices.

2.2.8 Overview of Researches based on Effect of Metacognition on different variables

Table 2.4

<table>
<thead>
<tr>
<th>No</th>
<th>Name &amp; Year</th>
<th>IV/DV</th>
<th>Method &amp; Sample</th>
<th>Tools</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kramarski, Mevarech &amp; Arami (2002)</td>
<td>Metacognitive instruction/solving mathematical authentic task</td>
<td>Experimental 91 seventh graders</td>
<td></td>
<td>ANOVA</td>
</tr>
<tr>
<td>3</td>
<td>Kramarski (2008)</td>
<td>Metacognitive guidance/algebraic reasoning &amp; self regulation</td>
<td>Experimental 64 teacher</td>
<td>Test</td>
<td>Quantitative</td>
</tr>
</tbody>
</table>
Table 2.4 contd…

<table>
<thead>
<tr>
<th></th>
<th>Mevarech &amp; Amrany (2008)</th>
<th>Metacognitive Instruction/regulation of cognition</th>
<th>Experimental 61 high school student</th>
<th>MAI &amp; interview</th>
<th>Quantitative &amp; Qualitative</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Magno (2010)</td>
<td>Metacognitive skills/Critical thinking</td>
<td>Experimental 240 college student</td>
<td>MAI</td>
<td>Structural Equation Model</td>
</tr>
</tbody>
</table>

Researcher reviewed five study related to effect of metacognitive instruction on different variables. The dependent variables were mathematical authentic task, mathematical reasoning, critical thinking, regulation of cognition, algebraic reasoning & self regulation. All studies were conducted using experimental method. Sample selected were ranged from 61 to 384. Two study included high school students, one elementary school students, one college student and one teacher as a sample of the study. Three studies used test for the measurement of dependent variable and two used MAI. All study used quantitative methods for the analysis of the data.

Kramarski, Mevarech & Arami (2002) found that (COOP + META) group outperformed COOP group and positive effects of (COOP + META) method on lower and higher achievers. Kramarski & Mevarech (2003) found that (COOP + META) & (ID + META) group significantly outperformed (COOP + ID) group on metacognitive knowledge. Magno (2010) found that metacognition has a significant path to critical thinking. Mevarech & Amrany (2008) found that IMPROVE students outperformed their counterparts on mathematics achievement and regulation of cognition but not on knowledge about cognition. Kramarski (2008) found that (PD + META) group outperformed the PD group in using self-monitoring and evaluation strategies in algebraic problem solving.

2.2.9 Review of researches based on effect of constructivist approach

Anthony (1996) studied the active learning in a constructivist framework. This study examined 6th form (year 12) mathematics students’ use and awareness of learning strategies in their authentic learning environment. A major portion of the study was the development of a classificatory scheme of students’ learning strategies under the broad headings of cognitive, affective, metacognitive and resource management strategies. The participating class of 12 students was from a
coeducational secondary school in a provincial city in New Zealand. Throughout the school year data were collected by the researcher using non-participant classroom observations, interviews, student diaries, student work, and questionnaires. In addition, four case study students participated in a series of stimulated recall interviews. Case studies of two students detail contrasting passive and active learning behaviours. Examples of their strategic learning behaviours illustrate that having students involved in activities such as discussions, question answering, and seatwork problems does not automatically guarantee successful knowledge construction. The nature of students’ metacognitive knowledge and the quality of their learning strategies are seen to be critical factors in successful learning outcomes.

Akkuş, Kadayifçi, Atasoy & Geban (2003) studied the effectiveness of instruction based on the constructivist approach on understanding chemical equilibrium concepts. The purpose of this study was to identify misconceptions concerning chemical equilibrium concepts and to investigate the effectiveness of instruction based on the constructivist approach over traditional instruction on 10th grade students’ understanding of chemical equilibrium concepts. The subjects of this study consisted of 71 10th grade students from two chemistry classes of the same teacher. Each teaching strategy was randomly assigned to one class. The data were obtained from 32 students in the experimental group taught with instruction informed by the constructivist approach and 39 students in the control group taught with traditional instruction. The data were analyzed using analysis of covariance. The results indicated that the students who used the constructivist principles-oriented instruction earned significantly higher scores than those taught by traditional instruction in terms of achievement related to chemical equilibrium concepts. In addition, students’ previous learning and science process skills each made a significant contribution to the achievement related to chemical equilibrium concepts. In light of the findings obtained from the results, an additional misconception of chemical equilibrium concepts was determined in addition to the misconceptions in related literature. This misconception is that when one of the reactants is added to the equilibrium system, the concentration of the substance that was added will decrease below its value at the initial equilibrium.

Burrowes (2003) studied the results of a controlled experiment that tested the effectiveness of Lord’s teaching model: 1. Helping students achieve better grades on standard midterm exams. 2. Develop higher level thinking skills. 3. Modify their
attitude towards biology at a large, urban university. Researcher taught two large sections of General Biology I (cellular and molecular biology). One section was arbitrarily designated as control group (100 students) and was taught in the traditional manner, where instruction was based on lecturing, with little opportunity for student interaction. The other section was designated the experimental group (104 students) and taught following Lord's (1998) constructivist method. Groups were formed by four students seated next to each other in a row (Figure 2). After all cooperative groups were established; each group received a legal-size manila envelope that contained important information: 1. One Cooperative Group Composition sheet. 2. Four Student Profiles sheet. 3. One Group Answers to Class Work sheet. 4. Quiz sheet. This study provides substantiated evidence that teaching in a constructivist, active learning environment is more effective than traditional instruction in promoting academic achievement, increasing conceptual understanding, developing higher level thinking skills, and enhancing students interest in biology. In their final course evaluations, students in the experimental section commented that they enjoyed this class much more than their traditional classes felt they had learned more, made valuable friendships in their collaborative groups.

Kroesbergen, Van Luit & Maes (2004) studied the effectiveness of explicit and constructivist mathematics instruction for low-achieving students in the Netherlands. In this study they compared the effects of small- group constructivist and explicit mathematics instruction in basic multiplication on low-achieving students' performance and motivation. A total of 265 students (aged 8-11 years) from 13 general and 11 special elementary schools for students with learning and/or behavior disorders participated in the study. The experimental groups received 30 minutes of constructivist or explicit instruction in groups of 5 students twice weekly for 5 months. Pre- and posttests were conducted to compare the effects on students' automaticity, problem-solving, strategy use, and motivation to the performance of a control group who followed the regular curriculum. Results showed that the math performance of students in the explicit instruction condition improved significantly more than that of students in the constructivist condition, and the performance of students in both experimental conditions improved significantly more than that of students in the control condition. Only a few effects on motivation were found. They therefore concluded that recent reforms in mathematics instruction requiring students to construct their own knowledge may not be effective for low-achieving students.
Liang & Gabel (2005) studied the Effectiveness of a Constructivist Approach to Science Instruction for Prospective Elementary Teachers. This study examines the effectiveness of a new constructivist curriculum model (Powerful Ideas in Physical Science) in improving prospective teachers' understanding of science concepts, in fostering a learning environment supporting conceptual understanding, and in promoting positive attitudes toward learning and teaching science and chemistry in particular. A non-equivalent pretest–post-test control-group design was employed. Analysis of covariance and repeated measures analyses of variance were performed to analyze the scores on concept tests and attitude surveys. Data from videotaped observations of laboratory sessions and interviews of prospective teachers were analyzed by employing a naturalistic inquiry method to provide insights into the process of science learning and teaching for the teacher trainees. The interpretations were made based on the findings that could be corroborated by both methodologies. In the current study, the PIPS approach did not demonstrate statistically significant superiority either in improving students’ understanding of science concepts or in promoting positive attitudes toward science learning and teaching overall, especially for lower science performers. According to the classroom observation and interview data, it was found that a more cooperative and supportive learning environment had been created in the PIPS classrooms. The lower achievers in the PIPS classes enjoyed more and understood the target science concepts better than their counterparts in the ISS group did. It was found that all lower-achieving interviewees who perceived the actual learning environment as satisfactory also achieved a higher level of conceptual understanding and positive attitudinal development when compared with their counterparts who worked in a non-preferred learning environment. In contrast, the higher achievers in the ISS classes outperformed their counterparts in the PIPS group during the concept interviews, although more than 50% of them disliked the lecture type of teaching.
### 2.2.10 Overview of Researches based on Effect of Constructivist Approach

Table 2.5

Name & year, independent variable (IV) and dependent variable (DV), method & sample, tools and analysis of researches based on effect of constructivist approach

<table>
<thead>
<tr>
<th>No</th>
<th>Name &amp; Year</th>
<th>IV/DV</th>
<th>Method &amp; Sample</th>
<th>Tools</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Anthony (1996)</td>
<td>Constructivist framework/Active learning</td>
<td>Exploratory 12 Sixth grade math students</td>
<td>Observations, Interviews, student-diaries, Student workbook &amp; Questionnaire</td>
<td>Qualitative</td>
</tr>
<tr>
<td>2</td>
<td>Akkuş, Kadayificent, Atasoy, Geban (2003)</td>
<td>Constructivist approach/understanding chemical equilibrium concept</td>
<td>Experimental 71 10th grade students</td>
<td>Test</td>
<td>ANCOVA &amp; Qualitative</td>
</tr>
<tr>
<td>3</td>
<td>Burrows (2003)</td>
<td>Lords’ teaching model/achievement</td>
<td>Experimental 204 university students</td>
<td>Composition sheet, student profile &amp; class work sheet, quiz sheet</td>
<td>t-test</td>
</tr>
<tr>
<td>5</td>
<td>Liang and Gabel (2005)</td>
<td>Constructivist approach/concept understanding</td>
<td>Experimental 30-30 prospective teachers</td>
<td>Test &amp; Interview</td>
<td>ANCOVA</td>
</tr>
</tbody>
</table>
Researcher reviewed five study related to effect of constructivist approach on different variables. The dependent variables were active learning, achievement and understanding concepts. Four studies were conducted using experimental method and one using exploratory method. Sample selected were ranged from 12 to 265. Two study included elementary school students, one high school students, one university students and one teacher as a sample of the study. Three studies used test for the measurement of dependent variable and two used interview, one used student-diaries, Student workbook & Questionnaire, student profile sheet, one group answer to class work sheet, one quiz sheet. Four studies used quantitative methods and one qualitative method for the analysis of the data.

Anthony (1996) found that nature of students MK and the quality of their learning strategies are seen to be critical factors in successful learning outcomes. Burrows (2003) found that teaching in a constructivist active learning environment is more effective than traditional instruction in promoting academic achievement, increasing concept understanding and developing higher level thinking skills. Kroesbergen, Van Luit & Maas (2004) found that math performance of students in the explicit instruction condition improved significantly more than that of students in the constructivist condition. Liang and Gabel (2005) found that PIPS approach did not demonstrate statistically significant superiority either in improving students understanding of science concepts. Akkuş, Kadayıfçi, Atasoy, Geban (2003) found that students who used the constructivist principles-oriented instruction earned significantly higher scored than those taught by traditional instruction in terms of achievement.

2.3 Implications for the Present Study

The available literature review indicates a dearth studies conducted on development of metacognition in constructivist condition and hence there is a scope for the exploration of opportunities to develop metacognition through constructivist approach.

Most of the studies on development of metacognition were conducted using exploratory method and case study method. This implies that these methods are most suitable methods to study this abstract concept in depth. Apart from these qualitative methods there is also scope to use quantitative method which could quantify the metacognition to substantiate the study result. Thus a mixed method of research can
give the complete picture of metacognitive development in terms of qualitative and quantitative data.

The samples selected by these studies were small as the methods used required small sample. The reason could be that the development of metacognition requires in-depth study with focused observation and interview. Thus the small sample helps to better understand the development of metacognitive skills. Therefore it is desirable to study small sample to know the metacognitive development in detail. Development of metacognition was studied on varied samples ranged from kindergarten students to teachers and adults. Thus any level of sample is suitable to study the development of metacognition.

Most of the researcher have used video-recording and interview as a tools for the data collection. Thus observation through video-recording and interview techniques are better tools to collect the data. Think aloud protocol is also useful tools to assess the metacognition. Apart from it journal or diary maintained by the student provides useful data regarding their metacognition and these tools should also be used. Metacognition can be quantitatively measured through self-report inventory and hence this tool should also be used to know how much metacognition has been developed. Data obtained related to metacognition is mostly qualitative in nature, because the construct metacognition itself is abstract concept, and hence the qualitative methods of analysis of data are most suitable techniques. For self report measures quantitative techniques could be used.

According to Artzt & Armour-Thomas (1992) there is importance of metacognitive processes in mathematical problem solving in a small group setting. This implies that group activity provides opportunity to develop metacognition. Hence it is better to conduct study in small group setting. Vukman (2005) finds that accuracy in metacognitive statements was significantly better in the mature adult and the younger adult groups. Leutwyler (2009) found that there is no development of students’ self-reported use of metacognitive learning strategies during high school. This implies that adult group should be taken to conduct the study for the development of the metacognition.

Yılmaz-Tuzun & Topcu (2010) found that metacognition and Constructivist Science Learning Environment has positive relationship. This implies that constructivist approach can be used to develop metacognitive skills. Sperling & Dubois (2004) found that knowledge and regulation component of metacognition
were related to each other. This implied that MK is important to develop MR and thus both should be develop to develop MS.

Keeping in view of the above implications, in the present study an attempt has been made to use a mixed method approach with small sample size, using in-depth interviewing, audio-recording of the discussion, reflective essays and metacognitive skill inventory, in order to study the development of metacognitive skills among pre-service student-teachers through constructivist approach.