Chapter III

REVIEW OF RELATED LITERATURE

- Studies Related to Mathematics Anxiety
- Studies Related to Cognitively Guided Instruction
REVIEW OF RELATED STUDIES

Review of related studies is an important part of research. For any worthwhile study an adequate familiarity with studies which have already been conducted in the selected area is necessary. Review helps the researcher to gather up to date information regarding what has already been done in the area of study. It helps to avoid duplication of research, to identify gaps in research in the selected area and to derive helpful suggestions.

This chapter has been devoted for presenting survey of studies related to mathematics anxiety and cognitively guided instruction. It also includes trend of research in mathematics anxiety as well as cognitively guided instruction. These are presented under the following headings.

- Studies Related to Mathematics Anxiety
- Studies Related to Cognitively Guided Instruction

Studies Related to Mathematics Anxiety

Following are the studies related to mathematics anxiety reviewed by the investigator. These studies were helpful in various stages of the present study. The studies were thoroughly analysed and a trend of research in mathematics anxiety was also prepared.

Daneshamooz, Alamolhodaei and Darvishian (2012) conducted a quasi experimental research to investigate the effect of mathematics anxiety and working memory capacity on mathematical performance of three groups of college students with three different learning methods, co-operative method, e-learning method and traditional method. Significant negative correlation between mathematics anxiety and mathematical performance and positive correlation between mathematical performance and working memory capacity
were found. It was also found that students in the cooperative learning groups had significantly higher achievement scores than students in the other groups. A significant interaction effect of working memory capacity and mathematics anxiety on mathematical performance based on students’ learning method was also found. The study revealed that with controlling the effect of mathematics anxiety, working memory capacity had significantly more effect on mathematical problem solving of students who studied their lessons in e-learning method than other groups.

Devine, Fawcett, Szucs and Dowker (2012) studied the gender differences in Mathematics anxiety and the relation to mathematics performance while controlling for test anxiety on 433 British secondary school children in school years 7, 8 and 10. No gender differences emerged for mathematics performance but levels of mathematics anxiety and test anxiety were higher for girls than boys. Girls and boys showed a positive correlation between mathematics anxiety and test anxiety and a negative correlation between mathematics anxiety and mathematics performance. Test anxiety was also found to be negatively correlated with mathematics performance, but this relationship was found to be stronger for girls than for boys. When test anxiety was controlled, the negative correlation between mathematics anxiety and performance remained for girls only. Regression analyses revealed that mathematics anxiety was a significant predictor of performance for girls but not for boys.

Hlalele (2012) conducted a study on 403 learners of mathematics in 18 rural high schools in the Free State Province of South Africa. It was found that all learners sometimes, often or always experience mathematics anxiety in academic settings. No participants indicated that they never experience mathematics anxiety in academic settings.
Ko and Yi (2011) developed and validated a Mathematics Anxiety Scale for Students (MASS). The final version of the scale consisted of 65 items that measure four domains of mathematics anxiety viz., nature of mathematics, learning strategy, test/performance and environment. This scale was administered to a nationally representative sample of 2,339 Korean middle school and high school students to validate the scale. Psychometric properties including descriptive statistics, reliability measures, factorial structure and correlations with external criteria were examined to provide validity evidence of the final scale.

Lyons and Beilock (2011) used functional magnetic resonance imaging to separate neural activity during the anticipation of doing mathematics from activity during mathematics performance itself. Subjects were 32 right handed university students. For higher but not lower math anxious individuals, it was found that increased activity in fronto-parietal regions when simply anticipating doing mathematics mitigated mathematics specific performance deficits. It was found that individual difference in how mathematics-anxious individuals recruit cognitive control resources during mathematics performance predict the extent of their mathematics deficits. This suggested that educational interventions emphasizing control of negative emotional responses to mathematics stimuli will be most effective in increasing mathematics competency rather than merely giving additional mathematics training.

Bekdemir (2010) conducted a study to examine whether negative mathematics classroom experiences affect mathematics anxiety in 167 pre-service teachers in a university in Turkey. Mixed – method explanatory approach was employed. The findings revealed that many pre-service teachers have mathematics anxiety and that the negative mathematics classroom experiences have a direct influence on mathematics anxiety in pre-service
teachers. It was also found that mathematics anxiety is substantially caused by the teacher’s behaviour and teaching approach. The percentage of students who had negative experience was found to go up with the transition from the elementary and junior high school to high school level.

Cavanagh and Sparrow (2010a) conducted a study to develop a construct model of mathematics anxiety. The study examined the possible causes or determinants of mathematics anxiety followed by clarification of the construct using a four-function model of construct specifications which lead to operational definition of the construct. The study proposed a eight domain situational model of mathematics anxiety.

Cavanagh and Sparrow (2010b) in their study attempted to measure mathematics anxiety based on situational model of mathematics anxiety. Two forms of a questionnaire were constructed. Data were collected from 50 primary school students of age 5 to 7. The Rasch Rating Model was used for scaling. The empirical results were used to refine the situational model of mathematics anxiety.

In their study Erden and Akgul (2010) examined the predictive power of mathematics anxiety and perceived social support from teacher for mathematics achievement of primary school students. The sample consisted of 292 students of seventh and eighth grades. Independent samples t-test, Pearson’s Correlation Coefficient and Multiple Regression analysis were employed. The results of the study revealed that an increase in mathematics anxiety reduces mathematics achievement but perceived teacher supports results in an increase in mathematics achievement for both boys and girls. It also revealed that mathematics anxiety and teacher support are significant predictors of students’ mathematics achievement. In the case of boys, mathematics anxiety was more powerful predictor of mathematics achievement while it was teacher support for girls.
Johnson, Smith and Carinci (2010) conducted a longitudinal study of pre-service female teachers’ mathematics anxiety and mathematics self concept. This triangulation study examined 102 female pre-service teachers of one University teacher training programme of United States over three periods of time: upon entering the pre-service teacher program, following completion of the program, and one year after completion of the program. Students who majored in mathematics or science, or who were earning their single subject credential in mathematics or science were excluded from the study. Separate one-way repeated measure ANOVAs for self concept and mathematics anxiety revealed increase in self concept and decrease in mathematics anxiety and this positive changes were found to sustain apparently one year after graduation from the program.

Krinzinger, Kaufmann and Willmes (2009) conducted a study on mathematics anxiety and mathematics ability in early primary school years. The main objective of the study was to longitudinally investigate the relationship between calculation ability, self-reported evaluation of mathematics and mathematics anxiety in 140 primary school children between the end of first grade and middle of third grade. Structural equation modeling revealed a strong influence of calculation ability and mathematics anxiety on the evaluation of mathematics but no effect of mathematics anxiety on calculation ability or vice versa, contradicting with frequent clinical reports of mathematics anxiety even in very young mathematical learning disabled children.

Rubinsten and Tannock (2010) conducted a study on mathematics anxiety of 12 children with developmental dyscalculia and 11 typically-developing peers. Participants completed a novel priming task in which an arithmetic equation was preceded by one of four types of priming words (positive, neutral, negative or related to mathematics). Children were required to indicate whether the equation
was true or false. Analyses of the data revealed that participants with developmental dyscalculia responded faster to targets that were preceded by both negative primes and mathematics related primes. A reversed pattern was present in the control group. The result suggested that low mathematics achievement due to developmental dyscalculia lead to mathematics anxiety. Further, arithmetic affective priming might be used as an indirect measure of mathematics anxiety.

Ayotola and Adedeji (2009) in their study examined the relationship between gender, age, general mental ability, anxiety, mathematics self efficacy and achievement in mathematics among senior secondary students in Oyo State, Nigeria. Stepwise multiple regression was used on the collected data from 1,099 students and the results showed that mathematics self efficacy is the best predictor of mathematics achievement followed by gender and mathematics anxiety. The contributions of age and mental ability to mathematics achievement were non-significant.

Farnsworth (2009) studied math performance as a function of mathematics anxiety and arousal performance theory. No relationship was found between mathematics anxiety and performance on a non-math task, but an inverse relationship was found between mathematics anxiety and performance on the mathematics portion of a working memory intensive math task. Mathematics anxiety was directly related to perfectionism and fear of negative evaluation. There was no relationship found between mathematics anxiety and processing speed, memory span, or selective attention. There was a significant effect of mathematics anxiety on working memory, but this effect was limited to a math intensive task wherein the low mathematics anxious group outperformed the moderate or high mathematics anxious groups.
Karimi and Venkatesan (2009) in their study examined the relationship between levels of mathematics anxiety, mathematics performance and academic hardiness among high school students and also examined the effects of gender. Participants were 284 students of eighth grade, selected randomly from 9 high schools in Karnataka State. Pearson correlation analysis and two independent sample t-tests revealed that mathematics anxiety has significant negative correlation with mathematics performance, but no significant correlation was detected with academic hardiness. Significant gender difference was found in mathematics anxiety but not in mathematics performance and academic hardiness.

Yüksel-Şahin (2008) investigated whether students’ mathematics anxiety differed significantly according to a group of variables. Participants were 249 fourth and fifth graders of Turkey. Independent sample t-test, one-way ANOVA and Scheffe test revealed that students’ mathematics anxiety differed significantly according to gender, liking for mathematics class, liking for mathematics teacher and achievement level in mathematics. It was also found that female students had higher levels of mathematics anxiety than their male peers. Students who liked their mathematics class and who liked their mathematics teacher had reported significantly lower mathematics anxiety. Results showed that students who were more successful in mathematics had lower degree of mathematics anxiety. But students’ mathematics anxiety was not found to differ significantly according to their grade level and their gender stereotypes regarding success in mathematics.

Zakaria and Nordin (2008) studied the effects of mathematics anxiety on matriculation students as related to motivation and achievement. The study revealed that the mean achievement scores and motivation scores of low, moderate and high anxiety groups were significantly different. A low but significant negative correlation between mathematics anxiety and achievement
and a strong significant negative correlation between mathematics anxiety and motivation were found. The study also revealed a significant positive correlation between motivation and achievement.

Anderson (2007) conducted an online survey to assess student anxiety and attitude response to six different mathematical problems. Sample consisted of 43 students from grades 4, 5 and 6. The six mathematics problems varied in type between traditional leveled tasks in the form of basic mathematical operations and rich tasks. Basic operations varied amongst three levels of difficulty and rich tasks varied amongst three degrees of complexity of context. A weak relationship was found between mathematics anxiety and attitude to the six problems presented. Some differences were observed between boys and girls for responses to rich tasks. Differences in both attitude and anxiety responses were found due to a variation of problem difficulty for traditional basic operations.

Ashcraft and Krause (2007) conducted a study on working memory, math performance and mathematics anxiety. The study showed how performance on a standardized achievement test varies as a function of mathematics anxiety, and that mathematics anxiety compromises the functioning of working memory. The study commented on developmental and educational factors related to mathematics and working memory, and on factors that might contribute to the development of mathematics anxiety.

Medeiros and Leclercq (2007) used an electroencephalograph (EEG) machine to measure the cortical activity of 6 volunteer undergraduate students while each memorized and recalled lists of both scientific and common mathematics words. A paired sample t-test showed that there was no significant difference in average cortical activity. It also showed that students who had high cortical activity when exposed to scientific terms also had high cortical activity when exposed to common terms.
Nasser and Birenbaum (2005) found that the correlation of mathematics anxiety and achievement is significant for Arab students and is not significant for Jewish students. For the whole sample the effects of mathematics anxiety on mathematics achievement was found to be not significant.

Sebastian (2005) conducted a study of some psychological variables discriminating between under and over achievers in mathematics among secondary school pupils of Kerala. A significant low negative relationship was found between mathematics anxiety and achievement in mathematics. Results revealed that the selected predictor psychological variables including mathematics anxiety are capable of classifying pupils as under normal and over achievers in mathematics.

Ma and Xu (2004) conducted a longitudinal panel analysis to determine the causal ordering between mathematics anxiety and mathematics achievement. Results of structural equation modeling revealed that prior low mathematics achievement was significantly related to later high mathematics anxiety but prior high mathematics anxiety not related to low mathematics achievement, across the entire junior and senior high school. Mathematics achievement was more reliably stable from year to year than mathematics anxiety. Statistically significant gender differences were found in the causal ordering of mathematics anxiety and mathematics achievement. Prior low mathematics achievement was significantly related to later high mathematics anxiety for boys across the entire junior and senior high school but for girls at critical transition points only. Mathematics anxiety was more reliably stable from year to year among girls than among boys.

In the study conducted by Tapia and Marsh (2004) on the effects of mathematics anxiety and gender on attitudes toward mathematics using a sample of 134 students enrolled in mathematics class in a state university. The results of
multivariate factorial model revealed that gender had no effect on attitudes towards mathematics, and gender and mathematics anxiety had no influence on attitudes toward mathematics. An overall significant effect of mathematics anxiety on self confidence, enjoyment and motivation with large effect size was found. Students with no mathematics anxiety scored significantly higher in enjoyment than students with high mathematics anxiety. Students with little or no mathematics anxiety scored significantly higher than students with some or high mathematics anxiety in measures of self confidence and motivation. Students with some mathematics anxiety scored significantly higher in motivation than those with high mathematics anxiety.

Uusimaki and Kidman (2004) in their study tested an intervention model than can be used to challenge mathematics anxiety amongst primary pre-service teacher education students. In the three phased intervention model, mathematics anxious participants engage in collaborative teamwork, specifically chosen mathematical activities, personal written reflections, and with innovative computer mediated software programs. It was found that the intervention model reduce mathematics anxiety, enhance the repertoires of mathematical subject knowledge, and a sense of identity as future primary mathematics teachers.

Woodard (2004) examined the effects of mathematics anxiety on post secondary developmental mathematics students as related to achievement, gender and age. The study was conducted on a sample of 125 developmental mathematics students. A significant negative relationship was found between mathematics achievement and mathematics anxiety. The results indicated that female mathematics students are significantly more mathematics anxious than male students. No significant age difference was found in mathematics anxiety.

Cates and Rhymer (2003) investigated the relationship between mathematics anxiety, fluency, and error rates in basic mathematical operations
among college students. Sample consisted of 52 students. Results suggested that the higher mathematics anxiety group had significantly lower fluency levels across all mathematical operations tests. No significant differences were found in error rates between higher and lower mathematics anxiety groups, which suggested that mathematics anxiety is more related to higher levels of learning than to the initial acquisition stage of learning.

Sherman and Wither (2003) conducted a longitudinal study of the relationship between mathematics anxiety and mathematics achievement. The technique of cross lagged panel analysis was employed. Observation of a cohort of 66 students was made twice a year over a period of five years as they progressed from school year 6 to year 10. The results revealed a negative correlation between mathematics anxiety and mathematics achievement. The data did not support the hypothesis that mathematics anxiety causes a lack of mathematical achievement, but supported the hypothesis that either the lack of mathematical achievement causes mathematical anxiety, or there is a third factor which causes both.

Ho, et al. (2000) studied the cognitive and affective dimensions of mathematics anxiety across samples of sixth grade students from China, Taiwan and the United States consisting of 671 students. The study compared the dimensions, levels, and relationship with mathematics achievement of mathematics anxiety. The results of confirmatory factor analyses were found to support the theoretical distinction between affective and cognitive dimensions of mathematics anxiety in all three national samples. The analyses of structural equation models provided evidence for the differential predictive validity of the affective and cognitive dimensions of mathematics anxiety. The study showed that the affective factor of mathematics anxiety is consistently related to mathematics achievement in the negative direction for all three national
samples. Gender-nation interactions were also found to be significant for both dimensions.

Kazelskis, et al. (2000) used correlational and confirmatory factor analytic techniques to examine the relationship between mathematics anxiety and test anxiety. The sample consisted of 321 university students. The results of the study did not provide strong support for a clear distinction between measures of mathematics anxiety and test anxiety.

Ma (1999) in a Meta analysis of the relationship between mathematics anxiety and achievement in mathematics among elementary and secondary school students examined 26 studies. The common population correlation for the relationship was found to be significant. A series of general linear models indicated that the relationship was consistent across gender groups, grade level groups, ethnic groups, instruments measuring anxiety, and years of publication. It was also found that researchers using standardised achievement tests tended to report a relationship of significantly smaller magnitude than researchers using mathematics teachers’ grades and researcher made achievement tests. Published studies tended to indicate a significantly smaller magnitude of the relationship than unpublished studies. No significant interaction effects were found among key variables such as gender, grade and ethnicity.

Newstead (1998) studied mathematics anxiety among 9 to 11 year old children. Mathematics anxiety of pupils taught in a traditional manner was compared with that of pupils taught in an alternative approach called Calculator Aware Number (CAN) curriculum emphasizing problem solving and discussion of pupil’s own informal strategies. Sample included 246 primary school students. The results revealed that mathematics anxiety is multidimensional. It was also found that students who were exposed to traditional approach reported more mathematics anxiety than those who were exposed to the alternative approach, particularly with regard to social, public aspects of doing mathematics.
Bessant (1995) conducted a study on factors associated with types of mathematics anxiety in 173 university students. The interrelatedness of various types of mathematics anxiety with attitudes toward mathematics, learning preferences, study motives, and strategies was studied. Factor analysis of the Mathematics Anxiety Rating Scale identified six factors. Correlation analysis indicated complex interaction patterns between attitudes toward mathematics and the six factors, depending on the overall level of anxiety experienced. Variation in orientation to learning was also found to be significantly related to specific types of anxiety, attitudes, and instructional factors.

Gierl and Bisanz (1995) evaluated students in Grades 3 and 6 on measures of mathematics anxiety, School Test Anxiety, and Attitudes towards Mathematics. The sample consisted of 95 students in a public school system, 47 students from Grade 3 and 48 students from Grade 6. Results revealed two distinct forms of mathematics anxiety: test and problem solving anxiety. Mathematics test anxiety was found to increase with age when compared to mathematics problem solving anxiety. This indicated that children become more anxious about mathematics test situations as they progress through school. It was also found that mathematics test anxiety was related, but not identical, to school test anxiety, and students in both grades were less anxious about mathematics tests than about academic testing generally. Older students tended to show more positive attitudes toward mathematics than did younger students. The relations between these attitudes and the two forms of mathematics anxiety changed between Grades 3 and 6.

Malini (1995) conducted a study to investigate the gender differences in certain psychological variables of the mathematical domain at secondary school level. No significant relationship was found between gender and mathematics anxiety. A low negative correlation was found between mathematics anxiety and
mathematics achievement and the gender difference in the relationship was not significant.

Sobha (1995) found that mathematics anxiety discriminate significantly between high, average and low mathematically able pupils.

Roy and Roy (1994) studied the interaction effects of mathematics performance, anxiety and achievement in mathematics and found that there is significant interaction effect of both the variables on mathematics achievement.

Jameela (1993) studied the gender difference in the relationship between mathematics anxiety and achievement in mathematics. No gender difference was found in mathematics anxiety and the variables were found to be negatively correlated.

Krishnakumar (1993) studied the effect of self concept and mathematics anxiety on achievement in mathematics of secondary school pupils of Kerala. Significant difference was found in the mean achievement scores of high, average and low mathematics anxiety groups. A low negative correlation between Achievement in Mathematics and Mathematics Anxiety was also found.

Coleman (1991) investigated the prevalence and intensity of mathematics anxiety among college students enrolled in mathematics education and English courses. No gender difference was found in mathematics anxiety and results indicated that factors other than mathematics anxiety should be considered to explain differences in male and female enrolment in certain mathematics courses. Negative correlation was found between mathematics anxiety and mathematics achievement.

Hadfield, Martin and Wooden (1992) conducted a study on a sample of 358 middle school students and found that mathematics anxiety and mathematics achievement are negatively related.
Mancini (1992) examined the relationship between mathematics anxiety, personality type, sex, age and prior mathematics course. No significant relationships were found between any of the variables studied.

Flessati and Jamieson (1991) investigated gender differences in mathematics anxiety and gender related response bias in mathematics anxiety using a sample of 60 male and 90 female undergraduates aged 19 to 49 years. Regardless of whether students were male or female, more negative mathematics experiences were reported by students with higher mathematics anxiety scores. It was revealed that the two findings that females are more self-critical of mathematics anxiety in them and are more self-critical of their performance in mathematics could explain gender difference in mathematics anxiety.

Lupkowski and Schumacker (1991) studied mathematics anxiety among talented students. The participants were 66 students attending the Texas Academy of Mathematics and Science in an early entrance to college program for talented students. Results indicated that these talented students were less math anxious than most unselected college students. But they were found to be more math anxious than a group of college students majoring in physics. No relationship between level of mathematics anxiety and grades or mathematics and Scholastic Aptitude Test-Mathematics scores was found for the group of talented students. Higher verbal scores and higher grades were found to be associated with lower levels of mathematics anxiety for males. These relationships were not found to be evident for females.

Miller (1991) conducted a study to find out the relationship of mathematics anxiety to gender and mathematics achievement. Results did not confirm that mathematics anxiety is correlated with gender and mathematics achievement.
Green (1990) studied test anxiety, mathematics anxiety and teacher comments in relation to achievement in remedial mathematics and found that test anxiety has a greater effect on mathematics achievement of students than mathematics anxiety.

In a study by Hembree (1990), results of 151 studies were integrated by Meta analysis to scrutinize the construct mathematics anxiety. The study revealed that mathematics anxiety is related to poor performance on mathematics achievement tests and is bound directly to avoidance of the subject. It also showed that variables which exhibit differential mathematics anxiety levels include ability, school grade level, and under graduate fields of study, with pre-service arithmetic teachers especially prone to mathematics anxiety. It also revealed that females display higher levels of mathematics anxiety than males. However, mathematics anxiety was found to link more strongly with poor performance and avoidance of mathematics in pre college males than females.

Hunsley and Flessati (1990) studied gender effect in mathematics anxiety and the findings revealed that mathematics anxiety is not truly a gender related phenomenon, but rather due to poor mathematical preparation.

Lewellyn (1990) investigated gender differences in mathematics achievement, and mathematics anxiety. Sample consisted of 241 adolescents in grades 7, 8 and 9. Even though females outperformed males in mathematics achievement, no gender difference was found in mathematics anxiety.

Meece, Wigfield and Eccles (1990) as part of a two year longitudinal research project studied 250 students of grades seven through nine. Structural modeling procedures were used to assess the influence of past math grades, math ability perceptions, performance expectancies, and value perceptions on
the level of mathematics anxiety of the students. A second set of analysis examined the relative influence of these performance, self perception and affect variables on students’ subsequent grades and course enrollment intentions in mathematics. The findings indicated that mathematics anxiety was most directly related to students’ math ability perceptions, performance expectancies, and value perceptions. Students’ performance expectancies predicted subsequent mathematics grades, whereas their value perceptions predicted course enrollment intentions. Mathematics anxiety was not found to have significant direct effects on either grades or intentions.

Wigfield and Meece (1988) conducted a study on mathematics anxiety in elementary and secondary school students. Confirmatory factor analysis of the obtained data revealed two components of mathematics anxiety, a negative affective reactions component and a cognitive component. It was also found that the affective component of mathematics anxiety related more strongly and negatively to children’s ability perceptions, performance perceptions and mathematics performance. But the worry component related more strongly and positively to the importance that children attach to mathematics and their reported actual effort in mathematics. Girls were found to report stronger affective reactions to mathematics. Ninth grade students reported experiencing the most worry about mathematics and sixth graders the least.

Mevarech and Ben-Artzi (1987) in their study examined the effects of Computer Assisted Instruction (CAI) with fixed and adaptive feedback on children’s mathematics anxiety and achievement. Multivariate and Univariate analyses of covariance on data collected from 245 sixth grade students revealed significant differences between CAI and non CAI treatments on six factors of Mathematics Anxiety. No significant differences were found between the two CAI treatments on any variable.
Clute (1984) studied the relationship of anxiety, teaching method and their interaction to mathematics achievement. Direct instruction discovery and direct instruction expository strategies were employed on 81 students in different sections of a survey course in college mathematics at two colleges. It was found that students with a high level of mathematics anxiety had significantly lower achievement than students with a low level of anxiety. It was also found that students with high anxiety benefited more from expository approach and students with low anxiety benefited more from discovery approach. It was also revealed that if the desired outcome is correct answers to high level questions, a discovery method may benefit students at all levels of anxiety.

Sepie and Keeling (1978) divided a sample of 246 eleven and twelve years old children, belonging to a school in New Zealand, into groups of over-achievers, achievers and under achievers in mathematics using regression equation based on the relationship between Otis I.Q. and mathematics achievement and employing the cut off procedure recommended by Thorndike. Analysis of Variance was used to compare the performances of the three groups on measures of general anxiety, test anxiety and mathematics anxiety. The results revealed that under achievers in mathematics are clearly differentiated from their achieving and over achieving peers in mathematics-specific anxiety than in either general or test anxiety.

Mathematics Anxiety- Research Trend

Mathematics learning and factors affecting mathematics learning including Mathematics Anxiety is a well analysed area in India as well as abroad. Many case studies, surveys, experimental studies, longitudinal and cross sectional studies had been conducted related to mathematics anxiety on a variety of
samples, using a variety of methodologies and utilizing various techniques of analysis. Quantitative, qualitative and triangulation studies were located which had studied mathematics anxiety in relation to variables like mathematics achievement, self concept, test anxiety, general anxiety, gender, age, mental ability, various teaching methods etc. Some studies tried to explore the reasons and consequences of mathematics anxiety while some others tried to clarify and define the construct. A number of studies were related to development of instruments for measuring mathematics anxiety.

With regard to the research on mathematics anxiety as related to teaching methods, some methods like Direct Instruction Expository (Clute, 1984), Computer Assisted Instruction (Mevarech & Ben-Artzi, 1987), Co-operative method (Daneshamooz, Alamolhodaei & Darvishian, 2012) were found beneficial for improving achievement of mathematically anxious students. An intervention model developed by Uusimaki and Kidman (2004) was found effective for reducing mathematics anxiety of primary pre-service teachers. The investigator was able to locate only one teaching approach helpful in reducing mathematics anxiety of primary students, namely Calculator Aware Number Curriculum (Newstead, 1998). The research trend analysed in this specific area support the research intension of the investigator to develop some form of instructional strategy to reduce Mathematics Anxiety.

Studies Related to Cognitively Guided Instruction

Guerrero (2014) examined teacher and administrator perspectives with regard to the adoption and implementation of Cognitively Guided Instruction at three elementary schools. A holistic exploratory case study analysis was conducted. Participants were elementary mathematics teachers representing grades one to six, school principals and one district office representative.
Classroom observations, teacher interviews, administrator interviews and a review of documents and materials related to Cognitively Guided Instruction were conducted. The data from these three sources were triangulated and analysed for emerging categories and subcategories. The findings of the study indicated few differences between the three school sites with regards to their adoption and implementation. Teachers’ and administrators’ perceptions of the adoption and implementation were found to be generally positive.

Moscardini (2014) carried out a study in Scotland which involved introducing the principles of Cognitively Guided Instruction to 21 mainstream elementary teachers. The study explored how these teachers used this knowledge to support all learners. The study was a qualitative one designed over three phases to support a comparison of pre- and post- intervention measures. Data from final interviews showed that all the participating teachers considered themselves to be more knowledgeable about children’s mathematical thinking. A shift away from the transmission of knowledge and procedures and towards encouraging pupils to make connections in their mathematical thinking was found.

Hankes, Skoning, Fast and Mason (2013) conducted a three year research study among Native American students identified as learning disabled. Methods used were problems based, consistent with those of Cognitively Guided Instruction and were culturally relevant. Participants were teachers in special education and inclusive education classrooms of grades kindergarten through 12. It was found that the target students had significant learning gains.

Hendricks (2013) conducted a quasi-experimental study to measure the impact of Cognitively Guided Instruction on Criterion Referenced Competency Tests (CRCT) achievement scores of 104 students who had been administered
the test from 2007 to 2010. The experimental group consisted of 53 students and control group consisted of 51 students. Using ANCOVA, the results revealed that a significant difference exist between mathematics scores of the experimental group and control group. Cognitively Guided Instruction was found to be instrumental in improving instruction and improving mathematics understanding. It was also found that as the dynamics of classroom social communication changes, children learn to think and act mathematically.

Spilde (2013) studied the effect of using a sequence of representations to solve word problems on students’ scores on pre-post assessments and daily problem solving. Mixed methods were employed to collect data. One group pre-test post-test design was used. Nineteen students ranging in age from 6 to 8 years participated. It was found that students’ problem solving abilities increased, students internalized the solution strategy process and students worked more independently on problems as their problem solving abilities increased. The triangulated results of the study showed that students solve Cognitively Guided Instruction style word problems correctly, with understanding at a high complexity level, and co-operatively with developed independence. It was also found that students increased the complexity of solutions used to solve problems and decreased the rate of guessing in answers to word problems.

Christenson and Wager (2012) reported that to provide guidelines for differentiated instruction in mathematics, staff from the Madison Metropolitan school district in Wisconsin created a pedagogical framework for teaching called “Balanced Mathematics”. The framework was based on Cognitively Guided Instruction, algebraic thinking and NCTM standards. It has four components. The teachers in the district were introduced to the framework through an instructional guidebook that contains many classroom resources, such as instructional organizers and sample activities and assessments.
Medrano (2012) studied the effect of Cognitively Guided Instruction on primary school students’ mathematics achievement, problem solving abilities and teacher questioning. Participants were second, third and fourth grade students of four elementary schools and nine teachers of these grades. Mixed method approach was used. Predominant strategy used by students to approach word problems was found to be direct modeling. It was found that third and fourth grade students demonstrated better achievement outcomes than regression prediction but not second grade students. It was also found that students did not understand questions being asked in many of the story problems and students had many misconceptions despite being asked many higher level questions.

Dowdy (2011) conducted a case study of 5 second grade teachers in two schools of one Southern California school district where Cognitively Guided Instruction was implemented in 2005 district wide for all elementary students. A qualitative analysis of observations, interviews, rubrics and district professional development records was done. It was found that teachers use Cognitively Guided Instruction in varying degrees. All observed teachers demonstrated most elements of quality Cognitively Guided Instruction.

Prusaczyk and Baker (2011) conducted a case study of a partnership of Southern Illinois University-Carbondale (SIUC) with twelve rural schools with high percentage of students in poverty. Participants were forty five teachers. Each one of them was given mathematics anxiety counseling and Cognitively Guided Instruction was used to enhance teachers’ mathematical knowledge and ability to apply discipline-particular teaching approaches. Analysis of various data collected during four years revealed significant reduction in the mathematics anxiety of teachers and significant increase in Algebraic reasoning. No significant change in number operations was found. It was also found that students of the participant teachers have made gains in achievement.
Helding (2010) conducted a study to develop a measurement instrument for student knowledge within educational interventions. The construct underlying the measurement instrument corresponded with student knowledge in Cognitively Guided Instruction contexts. Item types and content arrangement were according to Guttman pattern, and administered to kindergarten and first grade students with clinical interviews. In the IRT modeling of student responses and items, one dimension was ultimately extracted.

Moscardini (2010) conducted a study on a group of 24 children in 3 Scottish primary schools for pupils with moderate learning difficulties. This study showed how the pupils responded to word problems following their teachers’ introduction to the principles of Cognitively Guided Instruction. The study found that the pupils were able to develop their understanding of Mathematics concepts through actively engaging in word problems without prior explicit instruction and with minimal teacher adjustments. The pupils’ conceptual understandings demonstrated by their solution strategies within Cognitively Guided Instruction activities were not found consistent with classroom records of assessment.

Franke, Webb, Chan, Ing, Freund and Battey (2009) examined the classrooms of 3 teachers who had engaged in algebraic reasoning professional development. It was found that after the initial “How did you get that?” question a great deal of variability existed among teachers’ questions and students’ responses.

Musanti, Celedon-Pattichis and Marshall (2009) conducted a case study to investigate a professional development initiative in which a first-grade bilingual teacher was engaged in learning and teaching Cognitively Guided Instruction. The study explored the impact of classroom based professional development on a teacher’s understanding of teaching mathematics to Latin/o
students and issues of language and culture with which the teacher grappled while engaged in reflecting on students’ mathematical thinking. The findings showed that ongoing reflection, collegial conversation, and analysis of students’ work enhanced teacher’s understandings of students’ mathematical learning, and of practices that provide students opportunities to solve contextualized mathematics problems, to communicate their solutions, and to represent their thinking.

Jacobs and Ambrose (2008) studied teacher-student conversations in problem solving interviews in which a third grade teacher worked one-one with a child. After analyzing videotaped problem solving interviews conducted by 65 teachers while 231 children solving 1018 story problems, eight categories of teacher moves that, when timed properly, were productive in advancing mathematical conversations were found.

Lawson and Ramsey (2008) conducted a study to determine teachers’ perceptions concerning the use of Cognitively Guided Instruction in mathematics instruction. Participants were five teachers and two administrators who had attended professional development in Cognitively Guided Instruction. A Likert type survey was employed to collect data and percentage analysis was done for each survey item. The findings suggested that over all the teachers and administrators perceived Cognitively Guided Instruction training as beneficial and that improvements were made in student achievement. The results revealed that teachers intended to continue use of Cognitively Guided Instruction approach in their classrooms.

Empson, Junk, Dominguez and Turner (2006) analyzed children’s coordination of number of people sharing and number of things being shared in their solutions to equal sharing problems and also to what extent this coordination was multiplicative. In the study children’s solutions for equal sharing problems
in which the quantities had a common factor was documented. Data consisted of problem solving interviews with students in first, third and fourth grades (n=12). Two major categories of strategies were found and it was found that problems that included number combinations with common factors elicited a wider range of whole-number knowledge and operations in children’s strategies.

Fast (2005) attempted to determine if children in Zimbabwe, a developing country with cultures and educational experiences very different from those in the United States, could also potentially benefit from Cognitively Guided Instruction. Thirty five second grade Zimbabwean students’ mathematics problem solving attempts were assessed using the 14 Cognitively Guided Instruction problem types. It was found that their solution strategies were consistent with findings of previous research. Most of the students were at the direct modeling stage in their development and they had difficulty in solving more complex problems. Results suggested that Cognitively Guided Instruction offer considerable benefits for elementary school children in Zimbabwe.

Empson (2003) conducted an analysis of two low performing students’ experiences in a first grade classroom oriented toward teaching for understanding. Combining constructs from interactional sociolinguistics and developmental task analysis, the nature of these students’ participation in classroom discourse about fractions was investigated. Pre- and post instruction interviews documenting learning and analysis of classroom interactions suggested mechanisms of that learning. It was proposed that three main factors account for these two students’ success: use of tasks that elicited the students’ prior understanding, creation of a variety of participant frameworks in which students were treated as mathematically competent, and frequency of opportunities for identity-enhancing interactions.

Waxman and Tellez (2002) in their study synthesized research from 1990 to 2002 on effective teaching for English Language Learners (ELL), focusing on
instructional strategies and methods found to have most educational benefit to ELLs. The final synthesis consisted of 34 articles. Seven teaching practices were found to be effective in improving education of ELLs. It was found that Cognitively Guided Instruction has several positive components that can improve the education of ELLs.

Bowman, Bright and Vacc (2000) examined changes in 16 teachers’ beliefs about teaching and learning across a five year Cognitively Guided Instruction project. Beliefs scale was administered six times during the project and repeated measures analysis of variance and nonlinear regression analysis were done. It was found that during the initial year of implementation of Cognitively Guided Instruction, teachers’ beliefs declined and by the end of the second year teachers’ beliefs were found to recover to the same level evidenced immediately after the initial workshops. Little change was found in total scale and subscale scores after the second implementation year. The results revealed that long term, intensive support is needed by teachers to continue using Cognitively Guided Instruction approach in their mathematics instruction.

Bright, Vacc and Bowman (2000) conducted a case study of a third grade teacher across four years of implementation of Cognitively Guided Instruction. Data included annual interviews, written reflections of the teacher on instructional issues and observations of mathematics instruction of the teacher. It was found that the beliefs of the teacher shifted toward a constructivist view and remained stable throughout the project. By the end, the teacher was able to see student-student interaction as critical to development of mathematical thinking, view students’ struggles with mathematics ideas as desirable, help students to reflect, make explicit decisions about when children would share solutions and focus questions to help children to see mathematical structures.

Carpenter and Levi (2000) conducted a series of two studies in the context of Cognitively Guided Instruction to understand how to provide support
for children to reflect on their procedures in order to form generalizations from them and construct notations for representing their procedures and generalizations abstractly. In the first study, a group of eight students in a combination first and second grade class were taught eight lessons. It was found that some first and second grade children could deal successfully with a variety of true or false number sentences. The following year a case study of a combination class of grade first and second consisting of 20 students was conducted. The results were found to be consistent with the results of first study. The two studies revealed that students in the primary grades are able to engage in formulating, representing, and justifying conjectures even though their justification might not always be sufficient to validate all of the conjectures they are capable of identifying.

Vacc, Bowman and Bright (2000) conducted case studies of two teachers at their first year of teaching who had joined a five year Cognitively Guided Instruction project. Changes were documented in the areas of discourse, children’s thinking and instructional planning through analysis of transcribed annual interviews, teachers’ written responses to a variety of instruments, and classroom observations with post-observation interviews. Results revealed that by the end of the project, one teacher provided students with opportunities to solve a variety of problems but did not use what students shared to make instructional decisions. But the other teacher was found to make instructional decisions based on the knowledge about individual child’s mathematical thinking. Significant difference was also found between the belief scale scores of the teachers.

Clements, Swaminathan, Hannibal and Sarama (1999) investigated the criteria that preschool children use to distinguish members of a class of shapes from other figures. Individual clinical interviews of 97 children of ages 3 to 6
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emphasizing identification and descriptions of shapes and reasons for these identifications were conducted. It was found that young children initially form schemes on the basis of feature analysis of visual forms. It was also found that while these schemas are developing, children continue to rely primarily on visual matching to distinguish shapes. Results also revealed that children are capable of recognizing components and simple properties of familiar shapes.

Empson (1999) conducted a study to explore children’s fraction learning in a first grade classroom in which the teacher elicited and built on children’s informal knowledge of fractions. Sample consisted of 19 children. Pre tests and post tests indicated that children’s understanding of fractions had advanced. The results suggested that how children think about fractions is influenced not only by how their own knowledge is structured, but also by how the context for thinking about and discussing fractions is structured.

Vacc and Bright (1999) studied elementary pre-service teachers’ changing beliefs and instructional use of children’s mathematical thinking. 34 participants were introduced to Cognitively Guided Instruction as part of a mathematics method course. Belief-scale scores indicated that significant changes in teachers’ beliefs and perceptions about mathematics instruction occurred across the two year long sequence of professional course work and student teaching during their under graduate program. But it was found that their use of knowledge of children’s mathematical thinking during instructional planning and teaching was limited.

Battista, Clements, Arnoff, Battista and Borrow (1998) examined in detail students’ structuring and enumeration of two-dimensional rectangular arrays of squares. Twelve second graders were interviewed and research indicated that many students do not recognize the row-by-column structure
assumed in such arrays. Various levels of sophistication in students’ structuring of the arrays were found.

Bowman, Bright and Vacc (1998) in their study examined changes in 20 elementary teachers’ beliefs about teaching and learning that occurred during the first two years of a five year implementation of Cognitively Guided Instruction as the basis of mathematics instruction. To assess changes in teachers’ beliefs about teaching and learning mathematics, Cognitively Guided Instruction beliefs scale was administered before and after each of the four workshops. Results indicated that during the first year, teachers’ beliefs declined, despite receiving extensive support. It took two years of implementation for teachers’ beliefs to recover to the same level evidenced immediately after the initial workshops.

Bright, Bowman and Vacc (1998) conducted a study to examine the influence of teachers’ frameworks for human development, curriculum and mathematics on their interpretations of children’s mathematical thinking. The teachers in the study were 20 elementary teachers who were participating in a profession development project to help them implement Cognitively Guided Instruction. Data on teacher beliefs, interpretations of children’s solutions to Mathematics problems and instructional decision making were collected. Five frameworks were identified viz., developmental, taxonomic, problem solving, curriculum, deficiency. Results suggested that teachers focus most frequently and very consistently on the curriculum framework. It was also found that the increasing importance of the developmental framework was due to the increased attention paid by the teachers to the different kinds of solutions strategies used by students.

Carpenter, Franke, Jacobs, Fennema and Empson (1998) conducted a three years longitudinal study to investigate the development of 32 students’
understanding of multi-digit number concepts and operations in Grades 1-3. Students were individually interviewed five times on a variety of tasks involving base-ten number concepts and addition and subtraction problems. The study proved that children can invent strategies for adding and subtracting and illustrated both what that invention affords and the role that different concepts may play in that invention. About 90 percent of the students were found to use invented strategies. Students who used invented strategies before they learned standard algorithms demonstrated better knowledge of base-ten number concepts and were more successful in extending, their knowledge to situations than were students who initially learned standard algorithms.

Fennema, Carpenter, Jacobs, Franke and Levi (1998) investigated gender differences in problem solving and computational strategies used by 44 boys and 38 girls as they progressed from grades 1 to 3. The children were individually interviewed five times. In each interview, they solved tasks involving basic number operations and their application to more complex problems. No gender differences were found in solving number fact, addition or subtraction, or nonroutine problems throughout the three years of the study. Each year, there were strong and consistent gender differences in the strategies used to solve problems, with girls tending to use more concrete strategies like modeling and counting and boys tending to use more abstract strategies that reflected conceptual understanding. At the end of the third grade, girls were found to use more standard logarithms than boys. On the problems that required flexibility in extending one’s procedures, boys were found to be more successful than girls.

Franke, Carpenter, Fennema, Ansell and Behrend (1998) investigated changes over four years of three elementary teachers participating in Cognitively Guided Instruction professional development. Interviews and observations indicated that Cognitively Guided Instruction allowed teachers to
engage in ongoing practical inquiry directed at understanding their students’ thinking.

Hankes (1998) examined whether teaching methods employed in Cognitively Guided Instruction were compatible with the teaching methods of Native American Pedagogy. A kindergarten teacher implemented Cognitively Guided Instruction after participating in two 30-hour Cognitively Guided Instruction workshops. The results of a nine item test showed that the students demonstrated remarkable problem solving ability, indicating that Cognitively Guided Instruction is a culturally compatible way of teaching mathematics to Native American children.

Vacc, Bright and Bowman (1998) in their study examined changes in 19 teachers’ beliefs across the first two years of a professional development program in Cognitively Guided Instruction. The study involved five teams of mathematics teachers and teacher educators. Participants responded to three sets of open ended questions. It was found that participants changed their beliefs in three areas: teachers’ view of children, teacher and student roles, and skill acquisition and problem solving. The changes were found to vary by category and grade level.

Bowman, Bright and Vacc (1997) studied teachers’ beliefs and their implementations of children’s problem solving performance across the first year of implementation of Cognitively Guided Instruction. Sample consisted of 21 female teachers in grade 5. A transcript analysis of a dialogue between a first grade teacher and three students, a 48 item Beliefs Scale and two general items were completed by the teachers before each of the two workshops. Results of analysis of pre-post responses revealed that teachers’ beliefs changed significantly in ways that were consistent with Cognitively Guided Instruction tenets. Evidence cited by the teachers to support their assessment of students’
thinking also changed consistently with the implementation of Cognitively Guided Instruction. It was found that complex relations exist between these two kinds of changes.

Battista and Clements (1996) examined various conceptual structures that students construct in enumerating three dimensional cube array and the mental operations that underlie these constructions. 45 third and 78 fifth graders were interviewed and observed before and after a teaching experiment on volume. Results showed that students’ initial conception of a three dimensional rectangular array of cubes was an uncoordinated set of faces. It was also found that as students became capable of coordinating views, they see array as space filling and strive to restructure it as such. Those who complete a global restructuring of the array use laying strategies. Those in transition use local piece to piece restructuring strategies. These findings suggested that many students are unable to enumerate the cubes in a three dimensional array because they cannot coordinate the separate views of the array and integrate them to construct one coherent mental model.

Fennema, Carpenter, Franke, Levi, Jacobs and Empson (1996) conducted a longitudinal study to examine changes in the beliefs and instruction of 21 primary grade teachers over a four year period in which the teachers participated in a Cognitively Guided Instruction teacher development program. It was found that there were fundamental changes in the beliefs and instruction of the teachers. The gain in their students’ concepts and problem solving performance was found to be directly related to changes in teachers’ instruction.

Melton (1996) studied the change in black students’ performance when they worked with partners they selected. Participants were students of a fourth grade teacher. Using Cognitively Guided Instruction principles, the teacher observed students and adapted teaching method. Then a survey was conducted and the results revealed that the partnership was successful.
Knapp and Peterson (1995) conducted a study on teachers’ interpretations of Cognitively Guided Instruction. Twenty primary teachers were interviewed who, three of four years earlier, had participated in in-service workshop on Cognitively Guided Instruction. Three patterns of use of Cognitively Guided Instruction were found. These patterns were found to be related to the meanings teachers constructed for Cognitively Guided Instruction itself.

Behrend (1994) examined the problem solving processes of five second and third-grade students identified as learning disabled. Children’s independent and assisted problem solving abilities were assessed based on Cognitively Guided Instruction framework. Individual interviews and small group sessions were conducted. It was found that, given the opportunity, these students were capable of sharing their strategies, listening to other children’s strategies, comparing the strategies, justifying their thinking and helping each other to understand word problems. They were also capable of generating and generalizing their own problem solving strategies and did not need to be taught specific strategies.

Bright and Vacc (1994) as part of a project conducted a study to examine the effect of inclusion of Cognitively Guided Instruction in a mathematics methods course on the teaching performance of undergraduate pre service teachers. The sample consisted of 68 pre-service teachers at the University of North Carolina. The experimental group consisting of 34 students was given instruction on Cognitively Guided Instruction in their methods course and the control group was not. The beliefs survey revealed that pre-service teachers in both groups changed their beliefs to a more constructivist orientation during the program. It was found that Cognitively Guided Instruction pre-service teachers taught for meaningful understanding of mathematics concepts by the students but control pre-service teachers wanted students to reflect the mathematics
understanding of the teacher. The study also suggested that it is possible to teach pre-service teachers to use Cognitively Guided Instruction.

Lehrer and Jacobson (1994) conducted a three year longitudinal study of the development of children’s thinking about shapes; measurement, depiction and visualization. Based on the findings of the study conducted on first, second and third graders an experimental Cognitively Guided Instruction curriculum for teaching geometry was developed. After a series of workshops and a year of instruction using this curriculum, significant change in the beliefs of teachers about the teaching and learning of geometry was found. At the end of the year it was found that Cognitively Guided Instruction Geometry group showed large differences in conceptions of Geometry.

Schmitz (1994) conducted a study to increase middle-level teaching teams understanding of cognitively guided instructional strategies or brain-based learning theories and to promote the incorporation of these into the teaching of cross-curriculum thematic units. Twelve staff development modules based on a new perspective of learning were developed and implemented. Analysis of the survey and interview data revealed that middle level educators who were consistently involved in staff development sessions discussed the meaning of cognitive instruction, implemented more strategies within their classroom, and demonstrated understanding of cognitively guided instructional strategies’ relationships to curriculum integration.

Steinberg, Carpenter and Fennema (1994) conducted case study of a fourth grade teacher and 21 students of the teacher. The teacher taught mathematics using Cognitively Guided Instruction approach. Nine students randomly selected and were documented regularly. Observations, interviews and student assessments were collected. Four phases of teacher change were identified and teacher change was found to reflect in children’s solution
strategies. Results also suggested that it is possible to start implementing Cognitively Guided Instruction in fourth grade also.

Fennema, Franke, Carpenter and Carey (1993) conducted a longitudinal case study of one first grade teacher over a period of four years. The study was to understand how knowledge of children’s thinking in mathematics was used by the teacher to make instructional decisions. It was found that children in the Cognitively Guided Instruction classroom learned mathematics to a level that exceeds what is recommended by the NCTM standards.

Villasenor and Kepner (1993) compared the problem solving and computational skills of first grade students whose teachers had participated in staff development programme to learn to teach using a Cognitively Guided Instruction framework to that of first grade students whose teachers had not. It was found that students in experimental classes performed significantly better in solving word problems and completing number facts.

Knapp and Peterson (1991) conducted a study to examine teachers’ ideas of Cognitively Guided Instruction intervention four years later. The participants were 20 teachers who had participated in month-long workshops on Cognitively Guided Instruction as part of a large scale study. Ten of the teachers had participated in the experimental group and another 10 in control group in the larger study. Interview results revealed that their use of Cognitively Guided Instruction to teach mathematics varied widely from occasionally or supplementarily to mainly or solely. Three patterns of change in Cognitively Guided Instruction use were found. These patterns of change were found related to the meanings that teachers had constructed for Cognitively Guided Instruction.

Carpenter, Fennema, Peterson, Chiang and Loef (1989) studied teachers’ use of knowledge from research on children’s mathematical thinking and how their students’ achievement is influenced as a result. Twenty first grade teachers, assigned randomly to an experimental treatment, participated in a month long
Cognitively Guided Instruction workshop in which they studied a research based analysis of children’s development of problem solving skills in addition and subtraction. Other 20 first grade teachers were assigned randomly to a control group. Although differences in student achievement were modest, the differences found consistently favoured the Cognitively Guided Instruction treatment group.

Peterson, Carpenter and Fennema (1989) in their study examined the relationship of teachers’ knowledge of students’ knowledge to teachers’ mathematics instruction and to students’ mathematics problem solving. Twenty first grade teachers participated in a four week workshop in which they were given knowledge on children’s mathematics learning. Observations, interviews and questionnaires were employed. Correlation analyses showed significant positive relationships between teachers’ knowledge of students’ knowledge and mathematics problem solving achievement of students. Case analyses of knowledge and behaviour of the most effective teacher and the least effective teacher were found to support these conclusions.

Peterson, Fennema, Carpenter, Franke and Loef (1989) examined relationships among first grade teachers’ pedagogical content beliefs, teachers’ pedagogical content knowledge, and students’ achievement in mathematics. Sample consisted of 39 teachers. Results indicated significant positive relationships among teachers’ beliefs, teachers’ knowledge, and students’ problem solving achievement. Compared to teachers with a less cognitively based perspective, teachers with a more cognitively based perspective were found to make extensive use of word problems in introducing and teaching addition and subtraction. Cognitively based teachers showed greater knowledge of word problem types, children’s problem solving strategies and their children scored higher on word Problem Solving Achievement.
Carpenter and Moser (1984) studied children’s solutions to simple addition and subtraction word problems in a three year longitudinal study that followed 88 children from grades 1 through 3. Clinical interviews were used to identify the processes that children used. The results revealed that the children were able to solve the problems using a variety of modeling and counting strategies even before they received formal instruction in arithmetic. It was found that the invented strategies were continued to be used after several years of formal instruction. Four levels of problem solving ability were found.

**Cognitively Guided Instruction- Research Trend**

Review of the studies related to Cognitively Guided Instruction revealed that it is an emerging area of research. Most of the previous studies have investigated whether the Cognitively Guided Instruction knowledge shared in workshops had an impact on teachers and on students. The studies have used a variety of methodologies to study teachers including precise observations of teaching, paper and pencil assessments, individual interviews, and in depth case studies. Mixed methodology was also used. To assess children’s thinking, standardized tests, self developed paper and pencil tests and individual interviews have been used. The majority of the studies have been concerned with the learning and attitudes, problem solving strategies etc. of primary school students and with the thinking and instruction of their teachers. But studies have also been conducted on different samples such as students with learning disabilities, Native American, Black, Latin/o students and pre service teachers.

Researches on Cognitively Guided Instruction gave evidence for its significant effect on student achievement. It was also found to be effective for improving problem solving ability, number skills etc. Its positive effects for special education students are also found.

The review revealed gaps in Cognitively Guided Instruction related research. Majority of the earlier related studies were carried out by its programme
developers themselves. Only a small number of studies had been conducted by persons other than Cognitively Guided Instruction programme developers. Only a few studies had evaluated Cognitively Guided Instruction in terms of students’ mathematical performance. Most of the studies were carried out in United States of America. Investigator was able to locate only a small number of studies related to implementation of Cognitively Guided Instruction in other countries and was not able to locate any related study conducted in India.

As noted earlier, most of the studies reviewed relate Cognitively Guided Instruction to learning and attitudes of students and thinking and instruction of teachers. Only one study was located related to mathematics anxiety. In this particular study, it was used to enhance teachers’ mathematical knowledge and counseling was used to reduce their mathematics anxiety. No study was found to study the effect of Cognitively Guided Instruction on mathematics anxiety of students.

**Conclusion**

A thorough analysis of studies related to Mathematics Anxiety, Cognitively Guided Instruction was done. It helped to clarify the design of the study and to justify the selection of the research area. From the review it can be seen that study related to Cognitively Guided Instruction is a novel one in India and the investigator was not able to locate studies on teaching methods reducing mathematics anxiety of primary students also. The investigator hopes that the present study will be a worthwhile research contribution as the investigator had made an extensive survey of the studies related to mathematics anxiety and Cognitively Guided Instruction, and was able to identify the gap in this area of research.