CHAPTER II

REVIEW OF RELATED LITERATURE
The present study of group difference in computational skill is not based on any single theory. It being an attempt at examining the differences exhibited by certain defined groups in computational skills and the influence of factors like intelligence, class achievement in mathematics, socio-economic status, locale and gender on them, a review of available literature on Computational Skill is necessary and helpful. An attempt is made to review the important theories having bearing on arithmetic learning and the studies conducted in this area. Such a survey is expected to provide procedural guidelines for designing the new study and give theoretical orientation that will give strong indications of the nature of the hypothesis of the present study.

The collected information has been organised and summarised under two subtitles: (1) Theories Having Bearing on Arithmetic Learning. (2) Related Studies.

2.1 THEORIES HAVING BEARING ON ARITHMETIC LEARNING

Computational skill is the essential result that students are supposed to acquire through arithmetic learning at primary and secondary school levels. During every stage of arithmetic teaching and educational research related to this, questions arise such as, do mathematics teachers require theories and, if they do, theories of what type? The educationists found answers from the realities around them. They found that individual teachers accept even contradictory views.

At the time when calculators were introduced, it ignited a series of heated discussions about how and when they should be allowed to be used in schools. One
group asked whether multiplication tables would be used and whether students would achieve adequate computational skill if young children were allowed the use of calculators. Some others asked whether sensible use of calculators could enhance understanding.

There are teachers who hold that mathematics should be a silent activity with each of the children doing his own work while some other teachers advocate discussion and interactivity among pupils. co-operation and discussion between pupils. Is discussion important for all or do some pupils opt out and so learn nothing were some other questions.

In accepting a particular viewpoint or in taking sides in a particular issue, it could be said that the teacher has accepted a theoretical position. Everyday in schools, teachers adopt particular methods and strategies which they think would work. Such limited theories are based on experience, intuition, and perhaps on imagination. Some may be helpful, some dangerous. For example, is it desirable or dangerous to teach division of fractions in the primary school? It could be hazardous if children unable to understand what they are taught, in not understanding become confused and, frustrated and tend to reject mathematics seeing it as a meaningless and worthless activity. All these show that teaching cannot be done without accepting theoretical views, however limited and small-scale they are. It appears that teachers need theories as a basis for everyday decision-making in class rooms. Educational psychologists have formulated many theories for the study and teaching of mathematics such as behaviourist theory, cognitive theory, theory of meaningful learning and constructivist theory.

**Behaviourist theory**

The behaviourist theory evolved in the 19th century has since been influencing
teaching methods around the world. This theory lays emphasis on drill and practice in the belief that ‘practice makes perfect’. Class-room experiences of many teachers may lead them to believe that there should still be a place for practice, both mental and written. A specific example of the application of the behaviourist theory (practice-based learning) in mathematics is the use of multiplication tables.

**Stimulus Response theory**

The Stimulus Response theory or association theory of learning was prevalent before 1930. Also known as the Thorndike theory, the S-R Bond theory, and the connectivist theory, it set the pattern of teaching and learning for many years. Drill was the procedure which by the law of exercise would fix the bonds or connections and induce learning. Speed and accuracy in computation were the aims. Opponents called this theory the atomistic theory because it broke arithmetic, or any other subject to which it was applied, down to minute, unrelated parts for drill; and the mechanistic theory because the response came from repeated mechanical drill, with understanding playing little or no part in the learning experience.

**Gestalt theory**

By 1935 another theory of psychology, the organismic or, as it was generally called, the Gestalt theory of learning was making some impression on educators. Key ideas in this theory were:

1. The whole is greater than the sum of the parts.
2. The organism as a whole reacts to the situation as a whole; and
3. Insight and understanding have an important role in learning.

Translated into classroom procedures, these ideas would have the following results.

(1) They would treat number facts and computations as part of the whole
logical system of arithmetic and bring about comprehension of number relationships. (2) They would remove pressure for the memorizing and mechanical figuring of number operations, in view of their recognition of the pupil's inability to concentrate his mental power on recall items when other aspects of his organism - physical, social, and emotional - were in need of the teacher's attention. (3) They would emphasize basic concepts, including an understanding of the number system and of fundamental operations, and the development of principles and generalizations.

**Cognitive theories**

The Cognitive theory suggests different levels of achievement in the learning of mathematics. Robert Gagne, a former mathematics teacher, found that teachers needed to go back to an earlier level of achievement if a pupil could not attain the present objective being stressed in their curriculum. If a learner did not understand how to solve a mathematical problem, he/she might need to go back to studying the related generalization that is inherent in the problem. If the generalization is meaningful, the involved pupil might then be ready to solve the problem. In short, if a pupil did not attach meaning to what is presently being taught, going back to an earlier level of achievement is necessary.

Jerome Bruner, professor at Harvard University, advocates a structure of knowledge approach in mathematics. These structural ideas may be used by the learners again and again as they proceed to higher or complex learning on sequential grade levels. For example, the pupils may attain the following knowledge in increased levels of complexity:

1. Commutative and associative properties of addition and multiplication.
2. Distributive properties of multiplication over addition.
3. Property of closure.
4. Subtraction as the inverse operation of addition
5. Division as the inverse operation of multiplication

Bruner stressed the use of three kinds of materials in learning. They are enactive, iconic and symbolic. Enactive materials include concrete materials, and other objects for learner manipulation. Iconic materials include pictures, illustrations, video tapes, video discs, slides, film strips and other audio-visual aids. Symbolic materials are printed content of text books and library books and other abstract contents.

The eminent educational psychologist Jean Piaget stressed the importance of pupils going through specific maturational levels such as the sensori-motor, pre-operational, concrete and abstract levels. Biological maturation is salient when teachers ascertain what should be taught to pupils.

Theory of multiple intelligence

Theory of multiple intelligence developed by Howard Gardner, recognizes seven areas of intelligence. These are verbal or linguistic, logical or mathematical, visual or spatial, musical, bodily or kinesthetic, interpersonal and intrapersonal. According to him opportunities should be provided to pupils so that all seven intelligence may be developed.

Theory of meaningful learning

Ausubel’s theory of meaningful learning is a general theory and not specific to mathematics. Meaningful learning is a process through which new knowledge was absorbed by connecting it to some existing relevant aspect of the individual bias knowledge structure. If there were no relevant concept already in the minds, the new knowledge would have to be learnt by rote and stored in an arbitrary and disconnected manner. If new knowledge was assimilated within the existing
knowledge structure as related unit and, appropriate modification of the prior knowledge (accommodation) took place, the result was meaningful learning. It was therefore not necessary for all knowledge to be acquired by a process of discovery

Theory of Constructivism.

Constructivism is a modern theory which treats knowledge as an entity which cannot simply be transmitted from those who have to those who don’t have. Knowledge is something which each individual learner must construct for and by himself. This view of knowledge as an individual construction is referred to as constructivist theory.

Carpenter and Moser (1982) and MacNamara (1990) have suggested that strategies for operating with numbers introduced by teachers may run counter to the knowledge brought to school by the children and these may cause unnecessary disequilibrium.

Children generally base their informal arithmetic on counting strategies, but school mathematics programmes are based on combining and separation of sets. MacNamara pointed out the ability of young children to ‘subitize’, i.e. the ability of recognizing how many objects there are in a group without counting them. And most children commencing school have this capability for groups of up to five. MacNamara has claimed that this ability of the children is often ignored by teachers. Or the children are taught techniques which do not acknowledge subitizing and which therefore run counter to their natural inclinations.

These mainly mental calculations make sense to the child being based on real transactions in which goods or services are sold for cash. There is evidence to indicate that problems which make sense in this way are more easily solved than the de-contextualized ones of formal arithmetic. Schliemann (1984) also compared
the problem-solving capabilities of professional carpenters and their apprentices. These unschooled professionals sought realistic solutions to real problems and were comparatively successful. On the other hand, schooled apprentices were inclined to treat problems as school assignments and were often wrong.

These examples show the fact that children often seem capable of constructing at least some mathematical knowledge for themselves when schooled knowledge might be misunderstood, misapplied and even rejected. A major reason why children fail to achieve lasting learning is that the transmitted knowledge was never comprehensively grasped in the first place.

An important view of constructivism is that, if placed in a suitable environment, children can discover mathematics for themselves. One of the fundamental assumptions of cognitive learning psychology is that new knowledge is in large part constructed by the learner (Resnick and Ford, 1984). This assumption is the fundamental basis of constructivism.

In fact not mere transmission of knowledge is advisable. A combination of guided discovery and transmission is necessary. Or in other words, the knowledge must be constructed and reconstructed by each and every learner.

Also it is to be noted that constructivism cannot be equated with ‘free-for-all-activity’, ‘child-centered education’, ‘progressive education’ and even ‘discovery learning’. And constructivist teaching does not mean that the teacher gives up her authority and abrogates other responsibilities and obligations to the society.

Constance Kamii has a clear and firm observation to endorse this. According to her, the beginnings of arithmetic lie in learning about numbers and number combinations through playing dice games, leading to the memorization of number
combinations without any direct teaching or reinforcement. This may be regarded as a form of rote learning, but here the method works well, the use of games providing essential motivation. Subsequently, numerical questions posed by the teacher form the focus for class discussion of answers suggested by individual children, usually privately to the teacher, but sometimes openly to the whole class.

Thus the teacher remains very firmly in control and, as opposed to many group methods, the questions and suggested answers are presented on the chalkboard to the whole class. Drill and worksheets do not play any part at this stage, and pencil and paper are not available, so the emphasis is on 'mental' rather than on 'mechanical' or written arithmetic.

Number tasks are not invented by the children but are part of a carefully devised sequence of the teacher's making which is intended to provide for and enable progression in capability and knowledge. The teacher plays a critical role.

When errors are committed, it is said, these arise because the children are thinking and not because they are careless. Thus the task of the teacher is not to correct from the outside, but to create a situation in which the children will inevitably correct themselves. Kamii claims that children construct knowledge more solidly when they are encouraged to defend their ideas within a group or even a whole class. When other answers are offered by individual pupils, others declare whether they agree or disagree. Lack of unanimous agreement among children about a particular answer leads to their other suggested answers. When there is consensus, a pupil who provided the accepted answer is encouraged to explain how the answer was obtained. This is a very revealing aspect of the method, for there is normally variety in how children have constructed their solutions, so children have the opportunity to reflect on alternative approaches. For example, the task:
might lead to some children thinking of it in terms of 28-18-1, others as 27-17-1,
others as 20-10+7-8, others as 20-10- (8-7), and so on. In terms of generalities,
allowing children to construct reveals that most children deal with the tens before
the units.

2.2 RELATED STUDIES

The review of related studies was classified as follows:

2.2.1 Group differences in Computational Skills
2.2.2 Learning strategies on Computational Skills
2.2.3 Computational Skill among Special Education Students
2.2.4 Computational Skills of different Professional Groups
2.2.5 Other Studies related to Computational Skills

2.2.1. Group differences in Computational Skills

From the review of related studies it is seen that pupils are generally
categorised under different groups based on class achievement, problem-solving
ability, intelligence, socio-economic status, age, gender, locale, etc. Among these
all variables relevant to the present study are classified under three subtitles.
While Class Achievement in Mathematics is clubbed with Problem-Solving Ability
for placing under one subtitle, Intelligence is clubbed with SES and Locale for the
same reason. This is done because studies related to computational skill and
problem-solving ability, as well as intelligence and socio-economic status and
locale are comparatively few.
2.2.1.1. Studies related to Computational skill and Achievement in mathematics/problem-solving ability

Mathematics assumes a prominent position in our educational system. It plays a vital role in the Secondary School curriculum. Teaching of mathematics aims at students's understanding of the basic principles involved in mathematics and at developing their problem-solving ability.

Educational experts after deliberations and investigations conclude that, at present, the performance of students in mathematics is not up to the expectation. Studies also show that low achievers in mathematics are poor in arithmetic computation and problem-solving skills. Some of the studies are given below:

These studies were conducted on different samples, in different mathematical skills, on different contents by using different research designs.

Prakash in the year 1968 studied the predictive value of verbal intelligence test (VIT) and numerical ability test (NAT) in the achievement of physics, chemistry and mathematics at the intermediate level. Results showed that NAT is a better predictor of success in physics, chemistry and mathematics as compared to VIT.

Sumanan (1971) conducted a study on 746 pupils of Standard VIII, IX and X to get a general picture of the numerical ability of Secondary School Pupils. The study concluded that the agreement between numerical ability scores and school achievement is usually high.

Gupta (1972) conducted an investigation on backwardness in mathematics and basic arithmetic skills. The study consisted of 180 boys and 176 girls. It was found that low achievers in mathematics have poor command, whereas high achievers have good command, over basic arithmetic skills.

Mary (1981) studied the relationship between verbal reasoning and
numerical ability in mathematics. A positive relationship was found between numerical ability and mathematical achievement.

Englehardt (1982) conducted a study on the relative contributions of certain factors to individual difference and revealed that there is association between computational ability and high achievement in problem-solving.

Bain (1982) investigated the arithmetic skills of fourth and sixth grade low-achieving readers and the relationship among specific reading and arithmetic skills. From the results it was found that low-achievement readers generally evinced significantly lower arithmetic skills than high achievers. A 2x2 factorial analysis of covariance indicated that there was no interaction effect between reading achievement (low Vs. high) and grade level placement (fourth Vs. sixth).

Rastogi (1983) conducted a study on diagnosis in arithmetic as related to the basic arithmetic skills and their related measures. The sample consisted of 406 class VIII students. The study showed that. backwardness in mathematics was due to poor command over arithmetic skills.

Babbit (1990) conducted a study to detect error patterns in problem-solving. The data was collected from 431 fifth and sixth grade students. The problem-solving errors were divided into four broad categories—computation errors, operation errors, non-attempt errors and miscellaneous errors. The findings indicate not only that appropriate student error analysis leads to accurate feedback on the source of student-errors, but also that an understanding of error patterns can reveal understanding, conceptual misunderstanding or lack of problem-solving on the part of students.

Mac.Potempa (1990) conducted a study on computational skill and problem solving ability. Mathematical concepts and operations were used to measure
computational skill including operations with whole numbers, fractions and decimals. Four types of work problems in the curriculum were examined to measure the problem-solving ability. Results from the study indicated that computational skills and problem-solving are related and students who were able to correctly answer computational problems are more likely to correctly solve the word problems.

Van-Haneghan and Lamus (1990) carried out a study on the use of multiple standards of evaluation to detect errors in word problems. The relationship between mathematics achievement and error detection was also examined and it was found that high achievers detected more errors than low achievers.

Ambily (1993) examined the levels of attainment of certain basic skills in Mathematics of Standard V. Findings indicated that significant difference was found between numerical ability and mathematics achievement.

Sheehan and Mislevy (1993) analysed students’ achievement of college-level communication and mathematical skills. The tool used was the College Level Academic Skills Test (CLAST). No consistent improvement was noticed for ten years from 1982-1992.

Rabinouritz and Woolley (1995) examined the hypothesis that problem comprehension and computational process interact during the solving of arithmetic word problems. Results suggested the absence of any interaction between the two processes. The notion that automatized retrieval facilitates problem solving, as well as assertions suggesting that increasing computational requirements can interfere with problem-solving performances.

Hearne and Ramey (1998) constructed a central accountability policy that depend on school-based implementation. As part of this effort, a standards-based exit policy was implemented. Each school identified students as either meeting
grade level standards or not meeting these standards. They also investigated the application of the policy at various schools and its impact on students. Results indicated that teachers might rely on demonstrated computational skills as evidence of student-achievement.

Grouws and Cebulla (2000) summarized their research findings on best teacher practices in mathematics education. Findings show that student can learn both concepts and skills by solving problems; whole-class discussion following individual and group work improves student’s achievement.

2.2.1.2 Studies related to Computational Skill and Gender

Many studies were conducted to find out the effect of gender on computational skill. They are listed below:

Balakrishnan (1963) investigated how far the common errors in fundamental operations affect the achievement in arithmetic. The sample consisted of 500 pupils from eighth standard. Results showed that pupils committed more mistakes in mathematics and boys were found to be making less errors in fundamental operation than girls.

Iyer (1967) conducted a study on Construction of an Achievement test in Arithmetic for standard X. The sample consisted of 130 boys and 120 girls. It was found that girls were weaker in arithmetic and computation than boys.

A study conducted by Sumanan (1971) which was quoted earlier, revealed that the numerical ability of girls is superior to that of boys.

National estimate of school achievements is measured by the reading, and arithmetic results of the wide range achievement test (WRAT) for the non institutionalized population of the United States aged 12-17 years were examined.
by Hitchcock and Pinder (1974). The test results were presented by age, sex and educational level in their raw score form to permit comparison with other studies using WRAT. Percentile ranks and normalized standard score (Tscore) equivalent of the raw score have been included. Girls in the age range surveyed performed better than boys on word recognition and pronunciation task presented by WRAT. No significant difference between boys and girls in arithmetic computational skills was found.

In the study of Mary (1981) mentioned earlier, another major finding was that girls are superior to boys in their numerical ability.

A study conducted by Rastogi (1983) which was quoted earlier showed that there was no significant sex difference between students in their computational skills.

Bidwell (1983) attempted to measure and contrast the ability of pupils at the end of primary school to do simple calculation exercises and to do simple relational and practical problems involving number and operations. The results indicated that pupils tested were able to perform rote calculations than simple problem situations calling for little computation beyond basic facts, and that girls scored higher than boys.

Marshall (1984) examined gender difference in children’s mathematic achievement, solving computations and story problems. The sample for the study consisted of 30,000 sixth grade children in California. It was found that the girls were more likely than boys to solve computations successfully, where as boys were more likely than girls to be successful with story problem.

Salem (1985) conducted a study on basic mathematical skills and attitude towards mathematics possessed by students and their teachers. Their findings of
the study revealed that students scored 53.6 percent of the total comprehensive test on basic mathematical skills and their mathematics teachers scored 92.3 percent. No significant differences were found between males and females on the two instruments.

Tyler (1985) investigated the psychology of human differences. Batteries of achievement test were used to assess achievement rather than using school grade. It was found that boys performed better in problem-solving in mathematics, while, girls frequently performed better on computation.

An investigation by Bloor Phoebe (1988) on conceptual and procedural knowledge in the teaching of mathematical skills confirmed that instructional programme integrated with conceptual and procedural knowledge improved students ability to solve application (word) problems. It is also found that experimental girls were superior to both boys and girls in the control group, but no difference was found between boys and girls in either group.

Whalen (1989) compared computer-assisted instruction with traditional classroom instruction on seventh graders' computational estimation skills. Assessing computational estimation test (ACE) was administered to 88 seventh grade mathematics students of Indiana. Results showed that students on computer group did not significantly improved their scores on ACE, and boys performed significantly better than girls on computational estimation task.

George (1992) examined the computational skills of primary school students in relation to their intelligence and socio-economic status. It was found that girls were superior to boys in their computational skills.

A study conducted by Ambily (1993) which was quoted earlier revealed that there was no significant difference between the computational skill test scores of boys and girls.
Jessy Mathew (1994) conducted a study on the Computational Ability of pupils in Standard III which indicated that there was no significant difference in the computational ability of boys and girls.

An investigation by Sree Kumar (1996) on the Computational Ability of pupils in Standard III revealed that there was no significant difference in the computational ability of boys and girls.

The study conducted by Anil Kumar (1997) envisages identification of errors committed by Secondary School Pupils in some basic concepts of mathematics. The study revealed that there was significant sex difference between the boys and girls for the incidence of errors.

Sr. Rose Mathew (1998), who examined the factors affecting errors in Arithmetic Computation, found that boys commit more errors in arithmetic computation than girls.

2.2.1.3 Studies related to Computational Skill and Intelligence/Socio-Economic Status/Locale

A few studies were conducted to find out the effect of intelligence/socio-economic status/locale on computational skill are listed below:

The study by Sumanan (1971) which was quoted earlier revealed that the location of the school play a decisive role in deciding the numerical ability of Secondary School Students.

The study of Mary (1981), mentioned earlier, revealed that urban students were superior to rural students in their numerical ability.

An investigation done by Englehardt (1982), which was mentioned earlier indicated that there was an association between computation ability, intelligence and high achievement in problem-solving.
A study conducted by George (1992) quoted earlier, revealed that there was significant relationship between intelligence and computational skills of primary school students in the total sample as well as sub-samples classified on the basis of sex, locality and management of schools. There was also significant relationship between socio-economic status and computational skills of primary school students.

A study conducted by Ambily (1993), mentioned earlier, revealed that there was no significant difference between the computational skill test scores of pupils studying in schools in the rural and urban areas.

In the study of Jessy Mathew (1994) quoted earlier, it was reported that the Computational Ability of high socio-economic status pupils significantly higher than that of low socio-economic status pupils. Another major finding was that the Computational Ability of pupils studying in schools in urban areas was significantly higher than that of pupils studying in rural areas.

An investigation by Sree Kumar (1996), which was referred to earlier revealed that the Computational Ability of pupils studying in schools in urban areas was significantly higher than that of rural areas.

A study conducted by Sr.Rose Mathew (1998), already quoted, revealed that there was no significant difference in the number of errors committed in arithmetic computation in between municipal and rural area students.

2.2.2. Learning Strategies on Computational Skills

Several studies were conducted to find out the effect of certain specific learning strategies for improving the computational abilities of students. Almost all of the studies show positive results while adopting a strategy for the improvement of computational skills. The studies are given as follows:
Hughes (1973) investigated two methods used to teach multi-digit multiplication to fourth grade students: the lattice method and the distributive method. Computational ability, speed of computation, understanding of the multiplication process, and attitude towards mathematics were tested during the study. Data collected were analyzed by ANOVA. The groups using the lattice method were significantly more accurate and faster in computation than the distributive group, but there were no differences in understanding or attitudes of both the groups. Also there were no interactions attributed to urban, rural or inner city groupings.

Pascale (1973) developed and implemented a behaviour modification plan based on token learning schemes described for use in teaching basic computational skills to low-ability, poorly motivated graders. The token system with its reward schedule was outlined. Reinforcing activities such as team games, quizzes and drills were included in the plan. Findings showed positive results for the behaviour modification plans.

Searle (1973) designed an instructional programme that emphasized students' problem-solving skills instead of their computational skills. Fourth, fifth and sixth grade students were used as subjects. The regression analysis revealed that it is possible to account for a substantial portion of the variability in student responses using significant correlation between the deaf and hearing students on a rank-order of the problem difficulty level.

Weinstein (1973) conducted a study to determine differences in achievement of fifth grade students in 16 classes who were taught two of four mathematical algorithms by one of four instructional strategies, and their computational skills and ability to extend the algorithm were tested. No significant differences were found in the case of all four algorithms tested. Algebraic groups
tended to do better on simple algorithm extension tests than did the pattern groups; this was reversed for computation tests. No trend was evident in terms of performance of groups on complex algorithm computation tests.

Bien (1974) investigated the differential effectiveness of two instructional techniques for field-independent fourth graders. For one group, received worksheets contained perceptual structuring while for the other they received worksheets containing both perception and cognitive structuring. Field-independent subjects scored significantly higher than field-dependent subjects on problems requiring no additional structuring, while there was no significant difference between field-dependent groups when both perceptual and cognitive structuring were involved. Field-dependent subjects were significantly benefited by the use of cognitive and perceptual structuring overall on tasks involving computational skills.

Gensley (1974) emphasized the need for specialized instruction in mathematics. He suggested methods for teaching mathematical facts, concepts, described approaches and materials to develop students' 'understanding of mathematical principles' and explored ways to build skills and creativity. Recommended instructional approaches include using magic square to develop computational skills, adapting the seminar teaching/learning style to encourage higher intellectual skills.

Main (1974) evaluated Navy Mental Group for personal gains in competency of basic communication and computational skills after taking the Practical Arithmetic Self-Study course. Results showed that less than half of the trainees involved in the study were able to achieve ninth grade level. Findings recommended for effective training approaches.

Moyer (1974) studied whether the use of a probability unit in ninth-grade
general mathematics classes would yield student improvement in computational skill, arithmetic reasoning and attitude towards mathematics. Pre-tests indicated no significant difference between experimental and control groups on the criterion measures. In the post-test the only difference obtained were superior performance in the probability test by experimental group and improvement by experimental subjects in addition.

Ronshausen (1974) investigated the effect of programmed tutoring on mathematics achievement for kindergarten and first grade children. The programme used discovery-based activities, with each child working on a one-to-one basis with adult aid. Significant differences were found in concepts and computational skills when the “Programmed Math Tutorial” was used as a supplement to regular instruction.

Uprichard and Collura (1974) determined the effect of emphasizing mathematical structure in the acquisition of computational skills by seven-year and eight-year old children. The meaningful development-of-structure approach emphasized closure, commutativity, associativity and the identity element of addition; the inverse relationship between addition and subtraction; and place value. The control group essentially used drill-type activities. Analysis of covariance was used to analyze the data and results favoured the experimental group.

Jenson (1976) studied the use of creativity in teaching elementary school mathematics using sugar cubes, file cards, and other readily available objects. Results showed that the use of such games foster mathematical creativity while strengthening computational skills.

Malestky (1976) made a device that can be easily used for drill and practice on computational skills. Teachers using this device can vary content and the speed with which students should respond.
The study explored by Ronald (1979) on the validation of a model learning hierarchy posted for the computational skills in addition of fractions. Significant differences attributed to factors of six types.

Rosalic (1979) examined the effect of sequencing modes of instruction on computational skills. No significant differences were found among the treatment groups.

William (1979) conducted a study on the effectiveness of hand-held calculators for the remediation of basic multiplication facts. Pre-test and post-test design was used for the study. Results showed that the series of drill activities is helpful for remediation of basic multiplication facts among low achievers.

Brame (1986) studied the use of strategies applied by high school students having limited estimation ability for the estimation of the answers to computational problems. Results showed that removing the time pressure did improve performance.

A study by Martinak (1986) had a cognitive perspective to compare the performance of students instructed to use regrouping methods with the performance of students allowed to use only a paper and pencil method for doing mental additions. It was anticipated that there would be differential improvements between multiple-strategy and single-strategy conditions.

Mich (1986) examined the relationship between the micro-computer instruction and instructional intervention on acquisition of multiplication number facts. The results indicated that group through micro-computer instruction scored high achievement.

Ball (1988) examined the effectiveness of a software package designed to be consistent with a fraction strip chart model. Five fourth-grade classes of two
Schools constituted the samples. It was found that when concrete materials and computers were used in combination, it improved students’ skill in fraction problem-solving.

Scott (1988) conducted a study of a computerized diagnostic inventory of basic mathematical skills. A computerized diagnostic mathematics instrument (CDMI/MI) was designed parallel to the commercial paper and pencil inventory published by McGraw Hill titled ‘The Diagnostic Mathematics Inventory Mathematics System’ (DMI/MS). The study used a sample of 64 fifth grade students determined eligible for elementary mathematics laboratories. They were given both tests in a repeated measures design. Analysis of the results showed that the CDMI/MS required significantly less time and fewer questions than the DMI/MS.

An investigation conducted by Jordan (1990) on the cognitive bases of young children’s solution strategies for addition and subtraction problems showed that no significant difference existed between the experimental and control groups. Pre-test and Post-test design was used for the study. Findings also showed that subjects in solution strategy level lagged behind operational development.

Clark and Stahle (1991) conducted a study to compare the achievement for the operations of multiplication and division on whole numbers of elementary grade students who were taught functional diagnostic strategies with that of a randomly selected group who were not taught informal diagnostic strategies. Results showed significant difference between groups, high mean scores in achievement are associated with the group taught through informal diagnostic strategies.

Effects of thematically integrated mathematics instruction on achievement, attitude and motivation in mathematics among the middle school students of the Mexican descent was examined by Henderson and Landesman (1992). Findings
showed that experimental and control group students made equivalent gains in computational skills, but experimental students (who received thematic instruction) surpassed controls in achievement on mathematical concepts and applications. The two programmes did not have a differential effect on students’ attitude towards mathematics, but motivational variables did predict achievement outcomes for both the groups.

An investigation on whether conceptually oriented instruction jeopardize students’ conceptual competence by Madsen and Lanier (1992) among ninth-grade general mathematics class showed that in one conceptually oriented class the average grade level equivalence for computational competence was increased from 6.5 grade level to 9.1 grade level and computationally oriented classes average grade level increased from 7.5 to 9.5 grade level equivalence. The results of this study suggested that conceptual understanding enhanced students’ conceptual competence and promoted more positive attitude towards mathematics. The results also suggested that computational procedures are neither learned nor retained through drill and practice exercises, without conceptual understanding.

McDonald and others (1992) explored students’ computational performance while at the computer through computer-administered testing situations. Students from grade three were randomly assigned to treatment order, computer assessment first or paper-pencil assessment first. Significant differences occurred in three areas: completion time, number of mental computation strategies utilized and errors in transferring information.

Van-Houten (1993) carried out a study on Rote vs Rules: Where in a comparison of rule teaching and correction strategies for teaching basic subtraction, the children with learning disabilities were found to learn subtraction facts more
rapidly when a rule teaching and correction strategy was employed compared to learning facts by rote.

Metheny and Hollowell (1994) developed two mathematics activities using the theme of school lunch, menus and healthful eating habits to reinforce making predictions using computational skills. Findings supported the activities.

Schunk (1994) investigated the effects of goals and self-evaluation on self-regulation processes and achievement outcomes of fourth grade students who received instruction and practice on fraction operations. Results showed that providing a learning goal with opportunities for self-evaluation led to higher self-regulated performance, self-efficiency, mathematical skills and task orientation compared with providing a performance goal without self-evaluation.

Kolnowski (1995) examined the conceptual development of number and mental computation in grade one. The purpose of the study was to investigate the effect of instruction emphasizing conceptual level of number and mental computation on first graders understanding of number and on their addition and subtraction on computation and word problem performance. Achievement was significantly better on the experimental group. No significant difference was obtained on the CAT total score, but experimental students maintained their superiority in word problem-solving items.

Lee and Hee (1995) examined the errors committed by students while subtracting fractions. No significant difference between experimental and control groups was noticed in the pretest score. Improvement in computational skills was noticed for experimental group who used imagining pictures while solving problems.

Carroll (1996) examined the mental computational skills in University of Chicago School Mathematics Projects’ (UCSMP) curriculum. A timed mental
computation test was given to (n=78) fifth grade students who had been in the UCSMP curriculum since kindergarten. The UCSMP students outperformed the baseline group on all but one of the 25 items. During interviews UCSMP students rarely used a mental version of a paper and pencil method and tended to employ some of the methods used by good mental calculators.

Clariana (1996) studied the effect of Integrated Learning System (ILS) on the mathematics test scores of elementary school children. Results indicate the ILS software had its greatest effect on mathematics concept scores, which is contrary to the commonly held opinion that mathematics software is effective primarily in drill and practice of computational skills.

An investigation on the effects of using Suroban, a Japanese abacus by Gilmore (1997) revealed that students improved achievement in mental computation, increased interest in abacus and number computational skills; and developed relationship between abstract number ideas and concrete materials.

Gaulke (1998) investigated the effect of a computer algebra system (DERIVE) on students’ comprehension and computational skills in Brief Calculus, a first course for non-mathematic majors. Research results indicate better conceptual understanding by the group using DERIVE without the loss of pen-and-pencil computational ability.

A collection of ideas for the instruction and use of teacher-made instructional aids were examined by Reesink (1998). The articles were grouped into ten categories. Results supported using these constructional aids.

Ponidi (1999) examined the use of computer-aided software in many mathematics courses, especially in computational subjects. Many software packages were used in student lab- assignments such as FORTMAN, PASCAL, MATLAB, in order to accelerate their understanding of concepts and improve their computational
skills. The study found that the MAPLE was the most effective programme in solving and comparing.

Byrant and others (2000) examined whether five and six year olds understand that addition and subtraction cancel each other and whether this understanding is based on identity or quantity of addend and subtrahend. Findings indicated that children used inversion principle. Six-to-eight year olds also used inversion and decomposition to solve a+b-(b+1) problems. It was concluded that understanding may not be based on computational skills.

Brecht (2001) studied the relative effectiveness of co-operative learning, manipulatives, and their combinations. Pre-test and post-test Quasi experimental design was used. Sample consisted of fourth grade students. The result of analysis of variance showed that the main effects of teaching methods exist in different areas especially in computational knowledge and problem-solving skills in multiplication.

Tank and Zolli (2001) developed activities that are rich with child-friendly contexts that are fun and engaging and give students opportunities to gain computational skills while developing their own confidence in and enjoyment of mathematics. Activities include playing a game, reading a piece of literature, working with personal information such as name, body measurement, telephone numbers, interpreting newspaper data, working with money for shopping and making a penny collection and writing word problems about real and imagined experiences.

Problem-solving strategies of eight graders were examined by Lescault (2003). Six students enrolled in an eighth-grade were selected on the basis of their score on the mathematics subtest of the California Achievement Test. Results showed that students use different strategies during solving problems improved their meta-cognition.
2.2.3 Computational Skills among Special Education Students

The computational skills among the special education students such as underachievers, hearing-impaired, low-achievers, mentally handicapped, learning-disabled, disadvantaged, poverty level children (low-income children) and the like were also examined by many researchers. Some of the studies are given below.

Coleman (1973) examined the effects of a sequential computational skills mathematics programme for underachieving fourth grade pupils. The programme consisted of 12 units (from basic addition and subtraction facts to fractions computations). Results showed that mean increase in mathematics achievement was 2.5 years. Students’ attitude towards mathematics noticeably improved.

Frequencies and descriptions of systematic errors in the four algorithms in arithmetic were studied by Cox (1974) among upper middle income, regular, and special education classrooms involving 744 children. Errors were studied within levels of computational skill for each algorithm. Results showed that five to six percent of the children made systematic errors in the addition, multiplication and division algorithms.

Murray and Bexall (1975) conducted a review programme designed to assist teachers in assessing programmes for low achieving mathematics students. Programme provided for individual instruction, short-term goals, games level approaches and the like. Results showed that problem-solving ability and computational skills were improved.

Amodeo and Emslie (1985) a study on mathematics anxiety and competence of 57 Anglo and Hispanic pre service teacher students in the library media class served as the control group. Elementary and secondary students served as control group. Results showed that anxiety levels did not change but mathematical
competency increased for the group as a whole. Hispanic students showed higher anxiety levels and lower programme levels in both pre-tests and post-tests. No significant correlation was found between mathematics performance and anxiety.

Podsll and others (1992) compared Computer-Assisted Instruction (CAI) and paper and pencil practices in promoting automization of basic addition and subtraction skills. Ninety four elementary students (50 with mild mental handicap) constituted the sample. Findings suggested CAI was more effective but students with mental handicap required more practice than non handicapped counterparts to achieve automaticity.

Harding and others (1993) examined the effects of interactive unit on computational skills of students with learning disabilities and students with mild cognitive impairments. Eleven students aged 9-14 who were enrolled in self-contained special education classrooms received mathematics instruction through interactive unit. Significant differences were detected between pre-test and post-test scores in some area.

Scott (1993) examined the experience with the “TOUCH MATH” manipulative materials to help students with mild disabilities. Results showed that the manipulative materials helped to acquire math’s facts and computational skills.

Funkhouser (1995) investigated the effectiveness of procedures undertaken to develop number sense and basic computational skills in (n=12) learning-disabled students in a K-1 classroom. Results showed that all students were successful in recognizing and matching the number 0 to 5 and adding sums to five.

Lock (1996) offered guidelines and suggestions for adapting mathematics instruction when teaching students with learning disabilities in the general classroom. Techniques for teaching computational skills, solving algorithms and problem solving are offered. General techniques include increasing instructional time, varying group size and using real life examples.
The action research by Anderson and others (2001) developed a programme for improving mathematical problem-solving skills. The targeted population consisted of first grade students in a transient, middle class community as well as third and sixth grade students from a growing, middle to upper class in Illinois. Analysis shows that the teachers were not consistent when implementing the problem-solving skills needed for success across grade levels and that students lacked the ability of self-monitoring and applying a variety of problem-solving strategies to mathematical tasks.

2.2.4 Computational Skills of different Professional Groups

While surveying the studies based on computational skills it was noticed that some studies were conducted to examine the computational ability and its effect in connection with their profession. The studies are given below.

Eisenberg (1973) analyzed computational errors made by teachers of arithmetic. The diagnostic computational test was given to 22 arithmetic teachers in 1930 and to a similar group of 35 elementary school teachers in 1973. The purpose was to compare and contrast computational errors made by the teachers. Findings revealed that 1973 teachers possess, on the average, more computational skills than the 1930 teachers. Both populations had troubled with fractions, decimals and percentage problems.

Anderson and others (1993) studied over 60 percent of 533 local government units, where they found many of the workers lacking in basic skills, which impeded mobility and affected customer service. About 26 percent could improve by basic skill training or making accommodations for lack of language or computational skills.

A study by Smith (1993) compared the conceptual understanding of computational estimation strategies within the operations of addition and subtraction.
of incoming pre-service elementary teachers and those pre-service elementary
teachers. Results indicated that for both operations, addition and subtraction, senior
pre-service elementary teachers had not acquired more conceptual understanding
than fresh ones.

Villasenaor and others (1993) compared the problem-solving and
computational skills of first grade students, whose teachers had participated in
staff development to learn to teach using Cognitively Guided Instruction frame
work with that of first-grade students whose teachers had not. Significantly better
performance in solving word problems and completing number facts were found in
the case of the first group.

Ginsburg and Gal (1995) examined 60 adult students’ informal knowledge
of percent and its relationship to their computational skills. Sixty adults studying
in urban and semi-urban adult education programme were interviewed. Students’
responses were examined to determine the nature of their informal knowledge and
skills, and a number of patterns were identified. The range and fragility of student
responses and the diversity of knowledge gaps suggest the acquisition of isolated
ideas but the absence of elaborated frameworks.

Hutton (1998) examined the essentiality that nurses should be competent
at least in the mathematics that enables them to carry out medications accurately.
The results indicated that pre-registration nursing course should include an element
of mathematics to alert students to own their shortcomings and provide a means to
improve their computational skills before working in the clinical areas.

Mc Gowen and Kelley (2002) examined the mathematical growths of pre-
service elementary teacher over the period of a semester. The sample had an unusual
combination of very poor basic computational skills and a capacity for higher-
level problem solving. Findings showed that they acquired new insights and understandings about mathematics and experienced changes in their attitudes and beliefs.

An investigation was conducted by Tsao (2002) to see what level of number sense possessed by pre-service elementary school teachers and correlation among their mental computation skills and number sense. Regression analysis and t-test were used to analyze the data. Results showed that there exist a positive significant correlation between number sense mental computation skills. Also it was found that high ability group was more successful on each type of number sense item than the low ability group. High ability group had twice the frequency of correct responses of low ability group.

2.2.5 Other studies related to Computational Skills

Many other studies were conducted to examine the relationship between computational skill and some other variables which are closely related to computational skill. They are given as follows:

Major and Michael (1975) examined the relationship of achievement in a teacher-made mathematics test of computational skills in two way of recording answers and two workshop arrangements. Average performance on a test of arithmetic computation for both seventh and eight grade students depended upon whether a detached answer column, rather than the test paper itself, was employed for recording item responses. Seventh graders were affected by whether or not workspace was provided on the test form.

Romberg (1975) reported a document which deals with aspects of assessing student's performance and computational skills. First study grew out of a need for an instrument to measure student's speed at recalling addition facts. Second study
grew out of a need to develop a test of addition and subtraction. The third study deals with the question of item ordering on tests. The fourth study deals with three remedial methods of instruction for students at the second-grade level who were unable to perform two-digit addition with regrouping.

An investigation was conducted by Aiello (1979) on the relationship between selected aptitude variables from Guilford's structure-of-intellect model of intelligence and four types of error-makers on addition of fraction problems. The sample consisted of 136 seventh graders. They were classified into four categories (no error, careless, random, or systematic). Results showed that most errors on problems with same denominator were of the 'careless' type. In mixed-number problems there were fewer students classified into 'no error' category and more were classified into 'careless' category on proper fraction.

James and Wearne (1983) conducted a study to investigate students' difficulties with fraction by focusing on their understanding of part/whole relationships. Results showed that almost all students could deal successfully with one-half, while very few students could find one and one half of an object given whole object or unit.

Aeerr (1985) investigated whether student's understanding of the percent concepts depends upon the understanding of selected sub-skills of fractions and decimals-using Gagne's procedure for developing the learning hierarchy of percent concept. 182, seventh grade students from four schools of Southern Mississippi formed the sample. Results revealed that there is a moderate relationship between percent concept and selected subskills in fractions and decimals.

Salem (1985) conducted a study on basic mathematical skills and attitude of students and teachers towards mathematics. The study revealed that students
scored 53.6 percent of the total comprehensive test on basic mathematical skills and their mathematics teachers scored 92.3 percent. No significant differences were found between males and females on the two instruments.

Kachuck (1989) studied the relationship between students’ performance on fraction addition tasks and their understanding of fractional quantity. Ninth grade students represented the sample. The results showed that students who could not perform the fraction addition procedure had poor or no conceptual knowledge. Efficient students performed well on both conceptual and computational tasks.

McDonald (1989) conducted a study on the analysis of children’s performance on computer and paper and pencil administered assessments of whole number computation skills. Repeated measures design was used for the study. One hundred students in grade 3 - 6 constituted the sample. The results revealed that while working at the computers, students solved more problems correctly using mental calculations than they did on the paper version of the test.

Mohan S. (1990) examined the system of errors in problem-solution of primary school students. It was found that the errors are due to computation errors and conceptual confusion and suggested that computation errors could be rectified by providing constant practice.

Geary and others (1992) examined the relationship between counting knowledge and computational skills for 13 mathematically disabled (MD) first graders who showed a delay in acquiring mathematical skills and 24 non-disabled first graders. Results showed that MD children’s immature counting knowledge and poor computational skills at detecting counting errors underlay their poor computational skills on an addition task.

Yang (1997) examined the number-sense of the performance of sixth and
eighth grade students in Taiwan. 115 sixth graders and 119 eighth graders were selected for the study. Results suggested that students who could correctly carry out the exact computation by paper and pencil were not necessarily successful in applying these skills in non-computational situations. Significant differences were found between grade levels.

Mc Call (2000) investigated cognitive abilities and basic mathematics skills that are related to mathematics computation. Results revealed that normal control group scored significantly higher than the mathematics disabled group in basic numeration concepts such as place value estimation and number patterns. No group difference was noted on the working memory task.

Rhymer (2000) examined the effect of explicit timing with varying levels of mathematics tasks. 55 students in the sixth grade constituted the sample. The tasks include addition, subtraction and multiplication. Results indicated that explicit timing may be effective at increasing the number of problems corrected per minute and number of problems completed per minute without decreasing accuracy for mathematical skills that are better developed.

Kelley (2002) evaluates the National Numeracy Strategy (NNS) as a successful framework for promoting confidence and competence with numbers and measures, an understanding of the number system, a repertoire of computational skills, and the ability to solve number problems in variety of school contexts. Results suggest that taking steps to change children's mathematical belief and the use of mathematics away from school contexts.

Problem-solving strategies of eighth graders were examined by Advisor (2003). Students enrolled in eighth grade were selected on the basis of their score in the mathematics subtest of the California Achievement test. Results showed that
students used different strategies during solving problems and metacognition was improved.

Atallah (2003) examined the conceptions of mathematics and its utility in everyday life. The results indicated that around 86 percent of the participants hold broad conception of mathematics and viewed mathematics as useful for day to day routine work. Also arithmetic was cited as the most useful subject in mathematics. Findings suggest the need for more dynamic classroom environments for introducing a wide variety of meaningful contexts, for designing real life learning activities, and for presenting student with different faces of mathematics.

Vanhille (2004) examined the multiplicative reasoning of sixth grade students for operations on fractions. Results indicated that the experimental group and control group showed equal achievement.

CONCLUSION

An analysis of the literature reviewed reveals the following:

Out of the 100 studies located, 28 are having direct bearing on the topic of the present study, i.e. to examine the group differences in computational skills. Among these, 15 were on the relationship between class achievement in mathematics and problem-solving ability. They revealed that students who were lacking in computational skills were poor in basic facts; also revealed that computational skill and problem-solving ability were closely related.

There were 18 studies examining the relationship between computational skill and gender. Only five studies showed that 'Computational Skill' varied with gender. Similarly there were six studies on 'Computational Skill' and locale. Four of them showed some relationship between them. The studies involving
intelligence, SES and Computational Skill showed that there was clear relationship between Computational Skill and these variables.

Thirty eight studies other than the 28 studies mentioned in the beginning revealed the effect of certain learning strategies in improving the ability in computational skills. Most of the studies showed that if a specific strategy was followed, the ability in computational skill could be developed among students. Another ten among the cited studies were conducted among special education children to examine their computational skills. Almost all studies showed positive results when specific learning method or materials were used in the classroom for a specific period. Eight studies are given under the section Ability in Computational Skills and its Impact on their Professions. Relation between computational skills and some of the other variables were also studied. Sixteen studies were cited under this category

Studies under the above four categories reveal that, in general, students are lacking in computational skill and that it can be developed and improved by the application of proper learning strategies. Since computational skill falls into two major dimensions, computational speed and computational power, both areas are to be studied. But, studies relating to computational speed have been very few. Hence the investigator’s decision to conduct a study on group differences in not only the computational power but also the computational speed of Secondary School Students.