CHAPTER—VI

FINDINGS AND IMPLICATIONS
CHAPTER 6

FINDINGS AND IMPLICATIONS

This concluding chapter of the thesis presents the findings of the study in relation to the five research questions and three hypotheses which framed the research design. As the study was designed with qualitative and quantitative approaches, the details of the nature of the study in relation to the presentation of the report is discussed under.

6.1 Nature of the Study

Further, the findings of the study are discussed under.

6.2 Findings of the Study

- Findings on the comparative analysis of achievement among the Sighted and CVH on ADT (Objective I)
- Findings on diagnostic evaluation of performance of CVH on ADT (Objective II)
- Categorisation of errors
- Findings on analysis of performance on cognitive capabilities test of CVH (Objective III)
- Findings on appraisal of curriculum (Objective IV)
- Findings of performance on CCT in relation findings of performance on ADT for CVH

The implications of the findings are made apparent and recommendations on improving the mathematics curriculum is offered in general under:

- Implications for inclusive/integrated education setup
- Implications for development of Arithmetic Skills among CVH at lower primary level
- Implications for teacher training
- Implications for development of cognitive capabilities among CVH
6.1 NATURE OF THE STUDY

Current study on "Development of Arithmetic Skills among Lower Primary Visually Handicapped Children" was conducted using both qualitative and quantitative approaches. A concept map of the flow of the two approaches (qualitative and quantitative) used in the study is shown in Figure 7. The ideas encircled by double lines indicate the major sections that unfold in the study. This report based on the study begin with an 'Introduction', moves on to 'Related Literature', discusses both the qualitative and quantitative data collection 'methods', advances to quantitative results, qualitative findings and discussion on the qualitative findings separately and then the report ends with the implications of both the findings (qualitative findings and quantitative results).

The flow of ideas in the study (Figure 7) shows several stages in the design where both quantitative and qualitative approaches were used. The introduction advances the objectives related to description (qualitative), as well as comparisons - between CVH and Sighted (quantitative). The methods involving comparing groups - CVH versus Sighted using tests (quantitative), as well as interviews and classroom observations (qualitative). The results are interpreted for the quantitative data (statistical tests) and the qualitative data (discussion). Implications of the study are drawn from both the findings – quantitative results and qualitative findings. In summary, in almost all phases of this study, the investigator has attempted to include elements of the quantitative and qualitative approaches.
Figure: 7  Concept map of the flow of Qualitative and Quantitative approaches (Gogolin & Swartz (1992) used in the study "Development of Arithmetic Skills among Lower Primary Visually Handicapped Children". 

504
6.2 FINDINGS OF THE STUDY

6.2.1 Findings on the Comparative Analysis of Arithmetic Achievement among the Sighted and CVH on ADT (Objective I)

Development of Arithmetic Skills among Lower Primary Children with Visual Handicap as one of the primary objective (objective I) of the study aimed to compare the achievement of basic arithmetic skills among the Sighted and the visually handicapped children.

Objective 1

The study sought to assess the Arithmetic Achievement among Children with Visual Handicap in comparison to that of Sighted Children, both studying in V standard.

In pursuit of objective I following hypothesis were made -

Hypothesis 1

There is no significant difference between the V grade Sighted students and the CVH with respect to their overall Arithmetic Achievement.

The overall average performance V graders on ADT with a maximum score of 50 among Sighted and the CVH has not been encouraging with a low value of mean score i.e 36.90 percent and 28.36 respectively. Thus, it could be concluded that Sighted children have exhibited a better degree of Arithmetic Achievement than CVH. H1 was rejected at 0.001 level of significance.
Hypothesis 2

There is no significant difference between boys and girls in the CVH group with respect to their arithmetic achievement on ADT.

Hypothesis 3

There is no significant difference between boys and girls in the Sighted group with respect to their arithmetic achievement on ADT.

Gender differences were found to be insignificant in both the groups; statistically tested, leading to the acceptance of Null Hypotheses H2 and H3 of the study. It was concluded that boys and girls Sighted and CVH do not differ significantly in their development of Arithmetic Skills.

In an attempt to answer, the Research Question 1

To what extent have the lower primary Children with Visual Handicap developed arithmetic skills in terms of basic arithmetic concepts and operations? Do they differ in their Arithmetic Achievement from that of lower primary Sighted children?

mean percentage scores for each arithmetic task on ADT were calculated for the Sighted and the CVH. In general, it was observed that the Sighted children were better in their arithmetic achievement with respect to all the tasks. However, CVH showed slightly better performance on Number Tasks - Counting. However, in all the other arithmetic tasks of ADT, Sighted children have outscored the CVH.

From the results of the study, it could be concluded that the Sighted children are found to be better than the CVH in Arithmetic Achievement with
respect to the sample selected for the present study; but more research is needed for generalization of this finding with a larger sample covering CVH in different types of organisations such as integrated and inclusive education set up so that the teaching-learning factors are comparable.

Thus, there are important points to be considered in the curriculum of Mathematics, Arithmetic in particular, for CVH in special schools in comparison with that of the Sighted in regular schools. Sighted children have an edge over CVH in the acquisition Arithmetic skills through experience. The visual perception, which provides an enormous amount of information in just a glimpse enables the Sighted children to have rich experiences in a 'natural way', in which they experience as a 'whole', but the tactile perceptual experiences of CVH are always 'fragmented' (or in parts), the Sighted having 'Natural Learning' and the CVH having 'Mediated Learning' warrant for different approaches in the curriculum of CVH.

6.2.2 Findings on diagnostic evaluation of performance of CVH on ADT (Objective II)

Objective II

The study sought to diagnostically evaluate the performance of Children with Visual Handicap studying in V, VI and VII grades, on Arithmetic Tasks to identify/describe the errors/failures in attaining the mastery of selected arithmetic competencies.

In the pursuit of Objective II analysis had to be qualitative in nature in terms of diagnosing the errors and categorising them for further
interpretations. Diagnostic analysis was based on the individual performance of each CVH on ADT, by evaluating their answer sheet and also taking into account the field notes taken by the investigator during the collection of data. Analysis was considered for all three grades V, VI and VII (with N = 50) from the perspective of inquiring into the existence of cumulative deficiencies (if any). As already has been explained in chapter IV the ADT was also meant for analysing the arithmetic competencies acquired by CVH and a total of 28 competencies were identified under 6 main areas of arithmetic Number, Place Value, Addition, Subtraction, Multiplication and Division.

In pursuit of object II, following research question was raised:

**Research Question 2**

*To what extent does Children with Visual Handicap studying in V, VI, VII grades master the basic arithmetic competencies? In other words what is the percentage of success or failure in each of the arithmetic competency selected for the study?*

Analysis of performance of CVH on Number task revealed that Counting is the easiest among all the four competencies. Numbers with zero ending are perceived as odd number. The first digit from the left side of the given number is considered for identifying odd/even numbers, indicating that they do not read the whole number first (four digit numbers starting with thousand) but search for the single digit at the end of number; instead of unit place they identify the thousandth place. 'Completion of Series' and 'Ascending and Descending Order' competencies require the knowledge of
biggest and smallest numbers as well as ‘before’, ‘after’ and ‘middle’ position of the numbers. Surprisingly CVH have mastered the competency in completing the series upto 79%, but not in Ascending and Descending order (42%). This indicates insufficient experiences in Ascending and Descending order for CVH, which appears to be challenging for them in mental processing all the given numbers to identify them in Ascending and Descending order before answering through Taylor Frame. The knowledge of ‘ordinality’ of numbers should be meaningfully taught to CVH.

Thus, in the arithmetic area – Number, the most basic to all other higher order competencies, there are variations in attaining the mastery for CVH, unless the number competencies are mastered thoroughly, they cannot be expected to solve the higher order competencies. Moreover, there are CVH who have committed errors in VI and VII grade too. It is needless to say that remedial programmes have to be planned individually correcting their mistakes.

- Analysis of performance of CVH on Place Value items of ADT, percentage of responses not only indicates the variations in performance among the CVH of the study but also their problems in comprehending different kinds of Arithmetic tasks. Though all the four competencies aimed at assessing the knowledge and skills of Place Value, which paves the way for learning higher order competencies, the percentage of errors vary drastically from one competency to another within the arithmetic area – Place Value. As a good characteristic of any criterion referenced test, each competency on Place Value was tested on four items. So it was possible to analyse the
errors on individual items too as explained in section 5.2.2. Below are some indicators on errors to be taken care of, in providing remedial programme on Place Value for primary school children irrespective of their grades. The place value of ‘zero’ is the most difficult concept to understand for CVH. CVH from different grades (V, VI, VII) have erred in the various competencies on Place Value. These could be noted as cumulative deficiencies as children should have mastery in basic number concepts and skills to understand the place value.

The majority of the CVH have not mastered higher order tasks on four computational skills, however a simple task on Addition, Subtraction and Multiplication were mastered but not in Division. On the whole, the overall performance of CVH has been very disappointing on the basic computational skills of arithmetic without the understanding of which the child cannot learn higher order skills in mathematics.

31) 2467 + 3412
    ______

32) 8315 + 7463
    ______

33) 7257 + 9856
    ______

34) 4021 + 2107 + 7850

35) 8036 + 9906 + 6470

36) 19759 + 9976 + 887
    ______

With regard to addition the first two items (item 31, 32) without carryover show upto 70% and above mastery of the concept by CVH and then the sudden drop in the success rate in the third item to the sixth (item 33 - 36) competency with carryover provided ample evidence that CVH are yet to master Addition skill with carryover. Further, Addition with Zero (item 34, 35) and also the inadequate knowledge of Place Value was also found to be causes for errors occurred in addition.
With respect to Subtraction the errors account for an average of 28% ranging from 24 to 36 percent and it was notified that zero concept posed serious threat in solving subtraction problems. And in percentages of not attempted (60%) cases shows clearly that they have not mastered the basic facts of subtraction.

With regard to both Multiplication and Division the mastery level of competency is further low as compared to Addition and Subtraction, 20 percent and 16% success for Multiplication and Division the percentage of not attempted cases have steadily increased for Multiplication and Division (32% and 66% respectively) revealing that there is lack of understanding of the basic facts in solving multiplication and Division. The most difficult item in ADT was found to be Division with only 16% of children successful in that arithmetic task.

Thus, from the analysis of percentage of responses and observation of the errors in the response, it may be concluded that CVH need to have a firm understanding of place-value ideas before they can work effectively with the algorithms of arithmetic operations (addition, subtraction, multiplication and division). According to Wills (1971), developing the algorithms that work with multi digit numbers has to evolve from students’ understanding of place value, which . . . involves building connections between key ideas of place value – such as quantifying sets of objects by grouping by ten and treating the groups as units – and using the structure of the written notation to capture this information about groupings.
The above statement highlighting the role and importance of Place Value is equally applicable for CVH in their development of Arithmetic skills. In the absence of visual perception, concrete materials through tactile perception that are manipulative in nature are crucial for their Arithmetic learning. The results of the study on computational skills – Addition, Subtraction, Multiplication and Division subscribe to this view and the types of errors they commit in solving computational problems are to be carefully analysed for developing suitable remedial programmes. The errors that we identify among CVH could be compared with that of Sighted children which further indicates the differences if any, between the nature and type of errors they commit. Even though it was beyond the scope of this study to make a comparison of errors between the CVH and the Sighted within the sample of the study, an attempt has been made to refer the identified error categories among CVH to the available literature on the Sighted. This has been presented in the next section.

The low level of performance of CVH in this study with various kinds of errors in solving Arithmetic tasks warrants suitable remedial measures so that cumulative deficiencies could be taken care for upper primary children. It is very disappointing to note that majority of CVH from V, VI and VII grades of this study have not mastered multiplication and division skills; each subject has revealed his/her inadequate knowledge of zero concept at different situations and lack of knowledge on several aspects of place value.
6.2.3 Categorisation of errors

In the pursuit of objective II two research questions were raised. Findings for Research Question 2 was discussed in section 6.1.2. In this section, an earnest attempt is made to report findings on Research Question 3

What kind of errors the primary school Children with Visual Handicap commit in solving different kinds of arithmetic tasks pertaining to basic arithmetic concepts and operations?

Categorisation of errors was based on the Buswell and John (1925) system of categories. New errors that couldn’t be categorised under the available Buswell category was treated as New and thereby reported. For the purpose of categorising the errors, analysis of errors was carried out using the passive process wherein student work samples worked out by them on the Taylor’s Frame (modality used by the children to solve problems on ADT) for each task that were recorded in a diary was used. Summary table of the errors found for each computational task is given below in Table 66
Table 66

Summary of error categories identified for CVIH on Arithmetic Skills – Addition, Subtraction and Multiplication

<table>
<thead>
<tr>
<th>Area</th>
<th>Error Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addition</td>
<td>a2</td>
<td>Counting</td>
</tr>
<tr>
<td></td>
<td>a4</td>
<td>Forgot to add carried number</td>
</tr>
<tr>
<td></td>
<td>a6</td>
<td>Added carried number irregularly</td>
</tr>
<tr>
<td></td>
<td>a12</td>
<td>Used wrong fundamental operation</td>
</tr>
<tr>
<td></td>
<td>a13</td>
<td>Lost place in column</td>
</tr>
<tr>
<td></td>
<td>a16</td>
<td>Omitted one or more digit</td>
</tr>
<tr>
<td></td>
<td>a19</td>
<td>Derived unknown combination from familiar one</td>
</tr>
<tr>
<td></td>
<td>a23</td>
<td>Carrying when there was nothing to carry.</td>
</tr>
<tr>
<td></td>
<td>New</td>
<td>Subtracting carried number from the addend before addition.</td>
</tr>
<tr>
<td></td>
<td>s4</td>
<td>Errors due to zero in minuend</td>
</tr>
<tr>
<td></td>
<td>s6</td>
<td>Subtracted minuend from subtrahend</td>
</tr>
<tr>
<td></td>
<td>s8</td>
<td>Added instead of subtracted</td>
</tr>
<tr>
<td></td>
<td>s10</td>
<td>Used same digit in two columns</td>
</tr>
<tr>
<td></td>
<td>s11</td>
<td>Derived unknown from known combination</td>
</tr>
<tr>
<td></td>
<td>s23</td>
<td>Increased minuend digit after borrowing</td>
</tr>
<tr>
<td></td>
<td>New</td>
<td>Adds borrowed number to the minued before subtraction</td>
</tr>
<tr>
<td>Subtraction</td>
<td>s23</td>
<td>New</td>
</tr>
<tr>
<td>Multiplication</td>
<td>m10</td>
<td>Used wrong process – added</td>
</tr>
<tr>
<td></td>
<td>m12</td>
<td>Omitted digit in multiplier</td>
</tr>
<tr>
<td></td>
<td>m21</td>
<td>Multiplied by added</td>
</tr>
<tr>
<td></td>
<td>m26</td>
<td>Errors in writing product</td>
</tr>
<tr>
<td></td>
<td>m28</td>
<td>Illegible figures</td>
</tr>
<tr>
<td></td>
<td>New</td>
<td>Repeat multiplication while adding partial products</td>
</tr>
</tbody>
</table>

From the detailed analysis of the work samples, it was found that majority of the children exhibited deficiencies in
Addition

- counting on process from a given number
- carrying over the number to the next place value
- remembering to add the carried number by regrouping
- regrouping place value with zero to add the carried number
- adding zero to any number will result in zero and not in number based on place value and vice versa will result in number and not in zero.
- multicolumn addition with consistent carryover to the next place value

Subtraction

- counting on process from a given number
- borrowing number from the next place value if minuend is less than subtrahend
- subtracting a larger number in subtrahend from zero in minuend by borrowing a number from the next place values
- regrouping the number in the place value from which a number was borrowed
- subtracting zero from any number will result in number and not in zero
- subtracting digits with minuend and subtrahend digits as same will result in zero

Multiplication

- identifying process of multiplication as different from that of addition
- carryover to the next place value
- multiplication involving zero in multiplicand
Errors with respect to division could not be categorised as very few children attempted the item. Among those who have attempted the item did not complete it and hence, the procedure could not be analysed.

Thus, it was found from categorising the errors that CVH lag behind in understanding the basic facts of computational operations and further, the range of modalities used for learning and performing the tasks add to the complexities and may have possible influences in the type of errors committed by them. Diagnostic - Remedial teaching and review of the curriculum to accommodate the needs of the CVH as special learners is indispensable to the overall goal of providing education to Children with Visual Handicap.

6.2.4 Findings on analysis of cognitive capabilities of CVH (Objective III)

In pursuit of objective III which is restated below,

The study sought to analyse the performance of Children with Visual Handicap, studying in V, VI and VII grades, on selected cognitive capability tasks: (i) Classification, (ii) Seriation, (iii) Conservation of Number and (iv) Conservation of Quantity to study their attainment of concrete operational stage as Piaget has described.

Research Question 4 that was raised is stated below:

How far do the primary school Children with Visual Handicap attain the concrete operational stage on the selected cognitive capabilities – Classification, Seriation? How far do the primary school Children with Visual
Handicap attain the concrete operational stage - Conservation of Number and Conservation of Quantity as described by Piaget and his associates?

Findings on overall performance of Cognitive Capabilities Tasks shows that an overall mean score of 61% for the whole group irrespective of the age levels indicate a definite lag in the attainment of cognitive capabilities among CVH. Further, boys show a higher rate of attainment of cognitive capabilities with highest 74% at 16 years and 49% at 12 years in comparison to girls with highest 71% at 16 years and 47% at 12 years. Overall performance of boys at various age groups also shows slightly higher attainment of cognitive capabilities with 62% in comparison to girls with 60%.

As the first part of Research Question 4 (How far do the primary school Children with Visual Handicap attain the concrete operational stage on the selected cognitive capabilities – Classification, Seriation?) probed the development of cognitive capabilities among CVH with respect to Classification and Seriation, the present study revealed interesting findings. Development of the notion 'singular class' is not gradual with the grade levels. Further, the three modes of thinking – Perceptible, Functional, Nominal mode of thinking are neither uniform nor dominant in their occurrences in four different items, implying that CVH reason out the singular class differently in different situations. Also, there is an overall gradual increase in the attainment of stage III for each item among all the grade levels. Boys and girls show attainment of stage III at an equal level with highest of 92% for item 1 (parts of body versus spectacles). For, the remaining items (writing materials versus a pair of scissors; classroom furniture versus teacher; clothes versus detergent) attainment of stage III is not consistent indicating that boys and girls think
differently in different situations. Girls show a dominance of functional mode of thinking in comparison to boys with majority showing perceptible mode of thinking for all the items.

Classification of objects and events based on reasonable criteria is a critical ability underlying the growing cognitive sophistication that occurs with age. Findings of the study confirms the findings on the task of Classification among CVH by other researchers: Higgins (1973) found that children who had been severely visually handicapped since birth scored considerable worse on concepts involving abstract content than they did on the concepts involving concrete content. There was no corresponding difference for Sighted children.

From the analysis of seriation tasks it is observed that overall attainment of stage II (66%) in comparison to stage III (34%) indicate that even though CVH at the age of 13+ are prepared to seriate operationally cannot do so fully and still try by trial and error. Boys (44%) show a higher rate of attainment of stage III in comparison to girls (24%) indicating that operational level of thinking is better among boys than girls. Mandarvalli (1990) reports that the task Seriation, is easier for higher age groups than to the lower age groups and further that the age at which CVH generally become operational with respect to Seriation depends upon the nature of the materials involved. Seriation of length, volume and area appear to develop in CVH in that order as almost cent percent in thirteen and fifteen years could Seriate operationally length, 91 to 94% volume and 77% to 84% area respectively. However, findings from the current study show a clear lag of 4-5 years in development of operational Seriation among 13-15 years age group.
As the second part of the Research Question 4 (How far do the primary school Children with Visual Handicap attain the concrete operational stage - Conservation of Number and Conservation of Quantity as described by Piaget and his associates?) aimed to probe the attainment of Concrete Operational Stage with respect Conservation of Numbers and Conservation of Quantity, the present study revealed interesting findings. In relation to the performance on the task of Conservation of Number, there is a steady increase in the percentage of CVH in stage III and a steady decrease in stage I among implying a gradual development of conservation of number. Overall, 40% Transitory Conservers (TC) imply that though intuitive qualitative correspondence is set in but fails to progress to numerical correspondence. Further, with respect to Conservation of Quantity a gradual decrease in the number of CVH at stage III shows that there are more number of non-conservers (NC) and transitory conservers (TC) implying the prevalence of qualitative correspondence of mass and unavailability of the reversibility operation. Number of complete conservers is very low (16%) in the total sample of which boys (20%) show attainment of CC better than girls (12%). Girls (44%) exhibit non-conservation higher than boys (36%) whereas it is reversed in case of achieving transition stage wherein boys (44%) when compared to girls (24%).

Overall, total CVH Complete Conservers (CC) with respect to conservation of number (50%) is significantly higher than that of total number of CVH Complete Conservers (CC) with respect conservation of quantity (16%) implying CVH are better conservers in numbers against conservation of quantity. Even with respect to gender boys (60%) show higher rate of
conservation of number in comparison to their (20%) rate of conservation of quantity; girls (40%) also show a higher rate of conservation of number in comparison to their (12%) rate of conservation of quantity.

Gottesman (1976) found significant lags in the acquisition of various conservation concepts, but these lags tended to decrease with increasing age, among Children with Visual Handicap in the 8 to 11 years age range showing appropriate conservation of weight and substance. Gottesman (op cit) suggested that although the lags occur initially, Children with Visual Handicap become able to perform conservation tasks because of their “increased reliance on integrative processes of cognitive functioning, rather than a reliance on the less sophisticated sensory discrimination abilities” (p. 99).

6.2.5 Findings on appraisal of arithmetic curriculum in special schools (Objective IV)

Some of the noteworthy factors that evolve from the analysis of data regarding curriculum in section 5.5 are: insufficient resources in terms of availability of mathematics text book in braille; teaching-learning of usage of modality versus teaching of arithmetic skill (both the skills are simultaneously developed as one provides the modality to learn and the other provides the content strand for learning the modality); pace of teaching-learning as the group is heterogeneous, some children may lag behind due to deficiency in conceptual understanding while others may lag due to motor ability in handling the device appropriately; insufficient instructional time devoted to teach mathematics; insufficient availability of resources for continuous
practice after the class instruction; insufficient drill and practice of arithmetic
skills at mastery level (a concept is introduced, few sums are practiced and
the teacher moves on with the next skill – personal interview with teacher,
Rangarao memorial school for Girls); need for in-service training for teacher.

From the classroom observations and the interviews conducted with
the various personnel of the institutions visited by the investigator, it is evident
that majority of the teachers will appreciate if improved textbooks with
strategies to teach arithmetic concepts specifically to CVH is also provided.
Further, they would also appreciate if newer concrete materials were provided
for introducing the arithmetic concepts to the CVH. Training in emerging
technologies would also be beneficial in equipping the teachers for much
needed curricular adaptations for teaching the CVH.

6.3 FINDINGS OF PERFORMANCE ON CCT IN RELATION TO FINDINGS
OF PERFORMANCE ON ADT FOR CHILDREN WITH VISUAL HANDICAP

Having discussed the findings on Arithmetic Diagnostic Test and
Cognitive Capabilities Test performance of CVH, it is interesting to note
certain cognitive stages that correspond with the success or failure of CVH
performance on ADT test items.

Because of late admission to the special schools of CVH the onset of
crude concrete operational stage as described by Piaget are delayed among CVH
as revealed in Mandarvalli (1990)'s study on “Cognitive Development among
Visually Handicapped” covering operations such as classification, seriation,
conservation of number and conservation of quantity. This provides a clue
that the lag in the attainment of concrete operations may be one of the
reasons for poor performance of CVH on ADT as found in the current study. Further, it could also be noted in this study that CVH have not understood the meaning of place value, which is the basis for understanding the numeration that in turn warrants the understanding of multiple classification as well as reversibility thinking processes.

Thus, it could be concluded that the poor performance of CVH on the arithmetic tasks may be due to the lag in their cognitive capabilities. However, an indepth research is needed to draw further conclusions.

6.4 EDUCATIONAL IMPLICATIONS OF THE STUDY

Mathematics, at least in the form of arithmetic, has an important place in the education of all – young and adult learners. Development of basic skills is necessary for performing higher order mathematics involving higher order mental processing. Learning of basic arithmetic is considered to be easier for Sighted in lieu of incidental learning that is not structured for them but is naturally available. However, for CVH in the absence of visual channel to register and interact with such incidental opportunities, experiences have to be created for them to experience the numbers. Yet, the conceptualisation is not holistic and there is a definite lag in the development of arithmetic skills. Further, constructivist approach in curriculum planning as emphasized by the National Curriculum Framework 2005 (National Curriculum Framework, 2005) necessitates us to consider the development of cognitive capabilities among the children. Understanding the process of cognition helps the teacher to design appropriate learning experiences for the child. Constructivist way of building knowledge recommended in the NCF (2005) is stated as "In the
constructivist perspective, learning is a process of the construction of knowledge. Learners actively construct their own knowledge by connecting new ideas to existing ideas on the basis of materials/activities presented to them (experience)” (p. 17). Further emphasizing the learner’s role in learning, NCF (2005) states that “collaborative learning provides room for negotiation of meaning, sharing of multiple views and hanging the internal representation of the external reality. Construction indicates that each learner individually and socially constructs meaning as he/she learns. Constructing meaning is learning. The constructivist perspective provides strategies for promoting learning by all. The teacher’s own role in children’s cognition could be enhanced if they assume a more active role in relation to the process of knowledge construction in which children are engaged. A child constructs her/his knowledge while engaged in the process of learning” (p. 17).

Thus, this study attempted to not only enquire the development of Arithmetic Skills among the CVH but also probe into the development of their cognitive capabilities.

Findings on the various aspects of the current study viz., development of arithmetic skills, cognitive capabilities status among CVH and the curriculum followed for CVH in the special schools for the visually impaired, the significant implications can be drawn. Implications of the study in relation to the findings of the study is presented below.

6.4.1 Implications for Inclusive/Integrated education setup

Eventhough the study focussed on CVH studying in special schools and compared their performance with Sighted in regular schools, the question
remains what would be the problems or challenges of inclusive/integrated education in catering to the individual needs of CVH in regular schools? The findings in the present study reveal that CVH lag behind significantly in their development of Arithmetic Skills at lower primary level specifically in the arithmetic operations of addition, subtraction, multiplication and division in comparison to Sighted children. Infact, the special schools selected for the study had recognised the specific needs of each CVH in their school but inspite of that their difficulties in learning basic arithmetic skills as revealed in the analysis warrant serious considerations. So, the integrated or inclusive setup for CVH should cautiously take into considerations the necessity of experience-oriented curriculum of CVH with sufficient training for both the teachers and the resource teachers.

In this regard, Thomas and Loxley (2001) have proposed that the nature of resistance to inclusive education has changed in recent years, from the principled to the pragmatic. While it seems that most educators now support the underlying principles of social justice and equity that contribute to the impetus for the inclusive education, opposition now centres on practical issues. Surveys of British principals cited in Thomas and Loxley (2001) indicate that segregated education is sought primarily for students with disruptive behavioural disorders, severe or multiple disabilities. Similarly, Bell and Dempsey (2001) have identified the severity of the child's physical disability and social maladjustment as significant factors in determining the segregated or inclusive education.
A significant feature of the inclusive schools movement is its de-emphasis on huge financial resources. Instead, its recurrent theme is that the most effective factor in improving outcomes for students with disabilities is the human factor - the quality of teaching force, and those who support teachers, in leadership and paraprofessional roles. The view that students with disabilities will be a continuing liability to the school community because of their intensive resource requirements and disproportionate impact on the school has some chance of being dissipated if it can be demonstrated that the inclusive schools approach leads to improvements for all students in a school.

6.4.2 Implications for development of Arithmetic Skills among CVH at primary level

6.4.2.1 Need for Curriculum Analysis for Children with Visual Handicap

The content and instructional process of mathematics – arithmetic in particular should be inspected afresh so as to make the mathematics curriculum not only relevant for general education of Sighted but also increased implementation ability of the curricular areas for CVH. The findings of the present study have provided ample evidence for the need for diagnostic evaluation leading to remedial programs for CVH in developing arithmetic competencies. The study focused only on basic arithmetic competencies, any evaluation could be aimed at the instructional objective of each competency at a higher level too. The need for diagnostic approach has been emphasised by many scholars (Reisman, 1982; Buswell, 1925; Westwood, 1987)

An appropriate curriculum addresses strengthening and using the intellectual dispositions, offer good processes about rich content, and results
in high-quality products. Visit to institutions, evaluation of textbooks and discussion with the teachers and heads of the institutions revealed that mathematics curriculum in its entirety as is available today is not feasible for teaching CVH. Concepts considered for the study primarily focused on developing the basic arithmetic skills of number, place value, addition, subtraction, multiplication and division. Findings of the study reveal that CVH significantly lag behind the Sighted in achieving the arithmetic skills, particularly in arithmetic operations and further even among Sighted the mastery level reached is below 80% thus implying the evaluation of curriculum from the perspective of not only improving the content strands but also addressing the variety of experiences required to build the skills. Concretised experiences are limited for both the Sighted and the CVH. For Sighted at least, there are some visual experiences in the textbook (vide Section 5.2.2.3 Supra) providing semi-concrete opportunities of learning, is lacking for CVH.

There is great need to stress on the implementation of concretised experiences for teaching basic arithmetic skills. In the absence of mastering the basic skills, attainment of higher skills is difficult and even if children do show their achievement on higher-level skills may lack conceptual understanding of those skills. Hiebert and Wearne (1992) study on conceptually based instruction found that conceptually based instruction seemed to facilitate somewhat higher levels of understanding, and this seemed to translate into higher levels of performance on tasks that exploited such understanding. Students who did not have a conceptual understanding of place value and related procedures could not ultimately modify and transfer their knowledge to new skills (namely addition and subtraction with
regrouping). Modification and adaptations are necessitated from the fact that achievement of CVH significantly lag behind that of Sighted and even among Sighted mastery level is not attained with respect to certain operations viz – Addition, Subtraction, Multiplication and Division. Though a relative higher performance is seen for simple problems, however with the increasing complexity of the problem and also the operation in the order of addition, subtraction, multiplication and division, performance level decreases indicating that a thorough review of the content and the pedagogy is necessitated. Also as pointed in the Professional Standards for Teaching Mathematics (NCTM, 1989) the rationale to bring about changes in mathematics curriculum centres around the changes in mathematics that are occurring with the proliferation of technology; and, an increasingly rich and reliable knowledge base about how students learn mathematics and about how teachers facilitate learning of mathematics. The reform perspective is rooted in the ideas of constructivism, which holds that learning occurs through the construction of meaning as children are actively engaged in meaningful activates. The authority for learning should reside within the student, whose understanding of mathematical concepts grows through his or her participation in well-chosen activities. The reform documents (NCTM as quoted in NH K-3 Math Curriculum Addendum – 2000) advocate for a series of major shifts in the environment of mathematics classrooms:

i). toward classrooms as mathematical communities – away from classrooms as simply a collection of individuals

ii). toward logic and mathematical evidence as verification – away from the teacher as the sole authority for right answers;
iii). toward mathematical reasoning – away from merely memorising procedures;

iv). toward conjecturing, inventing and problem solving – away from an emphasis on mechanistic answer-finding;

v). toward connecting mathematics, its ideas and its applications – away from treating mathematics as a body of isolated concepts and procedures.

Further, the National Curriculum Framework (National Curriculum Framework, 2005) highlighting some of the problems in the existing mathematics curriculum remarks that:

- A majority of children have a sense of fear and failure regarding Mathematics. Hence, they give up early on, and drop out of serious mathematical learning.

- The curriculum is disappointing not only to this non-participating majority, but also to the talented minority by offering them no challenges.

- Problems, exercises and methods of evaluation are mechanical and repetitive, with too much emphasis on computation. Areas of Mathematics such as spatial thinking are not developed enough in the curriculum.

- Teachers lack confidence, preparation and support.

- Findings of the visit to various institutions for the current study reveal that in the special schools for CVH the first two years of primary schooling (Grade I-II) is primarily devoted to the basic adjustment of children to the residential settings and also for teaching basic living skills of mobility.
training and preparing the student for higher learning by teaching reading
writing skills using Braille. Mathematics, taught at this level (if any) is
usually oral and rote memorisation of numbers, multiplication tables is
emphasised. Basic concepts of arithmetic including the cardinality and
ordinality of numbers, place value and operations (addition, subtraction)
begin from grade III with the introduction of a new modality to learn
mathematics – Taylor Frame. Only from Grade IV onwards do the CVH
feel comfortable in learning mathematics using Taylor Frame. Few children
feel still reluctant to sit in the class owing to overloaded drill using Taylor
Frame with which the child might not be comfortable (vide Section 5.2.2.6).
Emphasis on the various modalities of learning dilutes the focus on
understanding the mathematical concepts. This opinion of a teacher
(Teacher, personal communication, November 28, 1998) is reiterated by
learning Mathematics, can be attributed partly to visual impairment but to a
great extent to the inappropriate teaching methods and non-availability of
learning material. An over insistence on the use of conventional material
without adequate adaptation and methods which presume too much from
the Visually Handicapped child can only result in inadequate
understanding of the mathematical concepts, relation and operations. One
of the major stumbling block is an early introduction of the algorithms and
its development without any adequate understanding of the process or the
reasons behind the steps of the algorithms” (pp. 240-241).

Thus, the shifts in the approach to teaching mathematics to CVH
including materials needs to be revisited and re-oriented in line with the
National Curriculum Framework (2005) and also the shifts in the Mathematics classroom as suggested by NH K-3 Math Curriculum Addendum (2000).

6.4.2.2 Diagnostic - Remedial Teaching Methods/Strategies

Findings from the current study on the achievement of student performance on arithmetic tasks provides an insight into the difficulties and deficiencies in learning certain concepts and operations. Teachers will need to identify these deficiencies and recognise any other factors influencing the performance of the child (eg: pedagogy, teaching-learning material etc.) and adapt suitable measures to remediate the deficiencies.

A curriculum map that is based on an empirical analysis of what children find easier and harder in practice will provide a picture of learning from the perspective of learners as an entire group. Curriculum map enables to describe individual performances and interpret in the context of typical pattern of student results. Hence, while reviewing the curriculum it is essential to involve the teachers who are the best indicators of student performance. Task analysis of each concept combined with the method/strategy/materials to be adopted at each stage should be available for the teacher for reference while teaching. Appraisal of the curriculum conducted in this study reveals lack of such documents and hence, justifies the need for reviewing the arithmetic curriculum revival in the light of needs of CVH and the teachers teaching them the subject.

Though, curriculum map shows the performance of individual student in relation to the performance of the whole group and deducing certain patterns of abilities or deficiencies based on the group pattern, it does not
show an individual's results on the specific task. For that level of detail an individual map is useful. Such an individual map (e.g. vide Section 5.3.3) for a child is helpful in planning the remedial programme for the child. The program should focus on the specific difficulties faced by the child and should involve child in identifying the best-liked method/strategy for providing instruction.

Westwood (1987) has dealt with various commonsense methods to deal with the errors committed by children with special needs including Children with Visual Handicap. Westwood (op cit) has quoted Reismann whose prescriptive remedial program with three activity oriented levels of assessment is quiet noteworthy for CVH group also. Materials manipulation is very important for CVH as suggested by Piaget with the principle ‘action on object’ it helps in fostering the cognitive development.

Reisman (1982) strongly advocates that teachers construct their own informal mathematical skills inventory containing test items covering key concepts, knowledge and skills presented in earlier years together with essential material from the current year. Such an inventory can very conveniently indicate precisely what the child can and cannot do and will assist with the ordering of priorities for teaching. The following three levels of assessment may help the teacher to design appropriate assessment materials. It is likely that the first two levels will be the most applicable for children with learning difficulties. From the findings of the study related to errors committed by the CVH on ADT tasks and also from the analysis of performance on the cognitive capabilities task, a remedial program on the basic understanding of the concepts classification, concervation and
arithmetic operations is warranted. The three levels of assessment advocated by Reisman (1982) may be conveniently adapted for CVH by adapting different toys and activities suitable for perception by CVH. Details of the Reisman (1982) Three Levels of Assessment is given below:

Three Levels of Assessment

Level 1 (May be adapted at the end of Grade III for CVH)

If the child’s performance in basic number is very poor consider the following points. At this stage almost all the assessments will need to be made at an individual level, using appropriate concrete materials, toys, pictures, number cards, etc.

- Check the child’s grasp of vocabulary associated with number relationships (e.g. ‘bigger than’, ‘altogether’, ‘less’, ‘share’, etc.).
- Check the child’s conservation of number.
- Then check the following knowledge and skills in this order. Can the child
  - sort objects given one attribute (colour, size, shape, etc.) ?
  - sort objects given two attributes ?
  - produce equal sets of objects by one-to-one matching ?
  - count correctly objects to ten ? To twenty ?
  - recognise numerals to 10 ? To twenty ?
  - place number symbols in correct sequence to 10 ? to twenty ?
• write numerals correctly from dictation to 10 ? To twenty ? (For CVH this may be done on Taylor Frame)

• understand ordinal values (fifth, tenth, second, etc.) ?

• perform simple addition with numbers below ten in written form (e.g. 3 + 5 = ) ? With or without apparatus ?

• perform subtraction with numbers below 10 in written form ?

• count-on in a simple addition problem ?

• answer simple oral problems involving addition or subtraction with numbers below 10 ?

**Level 2 (May be adapted at the end of Grade IV for CVH)**

If the child’s performance in mathematics is slightly better than Level 1 consider the following areas:

Can the child

• carry out simple mental addition with numbers below 20 ?

• carry out simple mental problem-solving without use of finger-counting or tally marks ? (For CVH, instead of tally marks, manipulative materials like marbles and stick - 4 marbles and for the fifth marble a stick can be used. Number of sticks collected will be indicative of number of 5s - for 54 the representation will be |||||• for Sighted the representation with tally marks will be ||||| ||||| ||||| |||||

533
• carry out simple subtraction mentally as above? Is there a marked difference between performance in addition and subtraction?

• perform both vertical and horizontal forms of simple addition?

\[
\begin{array}{c}
  +5 \\
3 \\
\end{array}
\]

and \(3 + 5 =\) For CVH this can be done on the Taylor Frame).

• understand the commutative law in addition (i.e. that the order of items to be totaled does not matter)? Does the child see for example that \(5 + 3\) and \(3 + 5\) are bound to give the same total? When counting on to obtain a total in such problems does the child always count the smaller number on to the larger; or are these problems always solved from the left to the right regardless? \((2 + 8 = 12 + 5 = \)).

• understand additive composition (i.e. all the possible ways of producing a given set or total)? For example, 5 is \(4 + 1, 3 + 2, 2 + 3, 1 + 4, 5 + 0\).

• understand the complementary or reversible character of addition and subtraction? \((\& + 3 = 10, 10 - 7 = 3, 10 - 3 = 7)\).

• watch an operation demonstrated using concrete material (For CVH e.g. marbles) and then record this in written form (For CVH using Nemeth Code)?

• translate a written equation into a practical demonstration

• listen to a simple real-life situation described in words and then work the problem in written form? (Seven people were waiting at the bus stop. When the bus came only three could get on. How many were left to wait
for the next bus?) Use numbers below 20. Can the child work problems at this level mentally?

• recognise and write numerals to 50 ?

**Level 3 (May be adapted at the end of Grade V for CVH)**

If the child is able to succeed with most of the items in the previous levels or if he/she seems reasonably competent in many areas of basic match consider these questions. Can the child

• read and write numbers to 100 ? To 1000 ? Can he or she read and write sums of money correctly ?

• halve or double numbers mentally ?

• recite the multiplication tables correctly and answer random facts from these tables ?

• perform the correct procedures for addition of HTU and Th HTU. Without carrying ? With carrying in any column? (This is a common error as revealed from the current study as well [vide Section 5.2.2.5 ])

• understand place value with TU ? With Th HTU? This is a very common area of difficulty and may need to be checked very carefully.

• perform the correct procedures for subtraction of HTU and Th HTU? Without exchanging in any column? With exchanging? It is important to note the actual method used by the child to carry out subtraction. Is it ‘decomposition’ using only the top line of figures; or the ‘equal addition’ method using top and bottom lines?
• perform the correct steps in the multiplication algorithm? To what level of difficulty?

• perform the correct steps in the division algorithm? To what level of difficulty?

Another Math facts program proposed by Mercer and Miller in the Strategic Math Series (1991) features seven phases to teach basic math facts.

**Phase 1:** Pretest /Assessment  
**Phase 2:** Teach concrete application  
**Phase 3:** Teach representational application  
**Phase 4:** Introduce the "draw" strategy (should be replaced by “Do” strategy for CVH)  
**Phase 5:** Teach abstract application  
**Phase 6:** Evaluation  
**Phase 7:** Provide practice to fluency and develop problem-solving strategies

The strategic Math Series has yielded excellent results from testing (Mercer & Miller, 1992; Miller, Mercer, & Dillon, 1992). The field-test results indicate that 109 students with learning problems were able to acquire computational skills across facts: solve word problems with and without extraneous information; create word problems involving facts; apply a mnemonic strategy to difficult problems; enhanced rate of computation; and generalise math skills across examineers, settings and tasks.
Such a program would be of high value for CVH. Hence, curriculum planners should take into account the availability of such superior and tested models that could be equally adapted for CVH to identify the deficiencies so that appropriate diagnostic teaching may be adopted.

6.4.3 Implications for teaching methods and strategies

Significance of Teaching methods and strategies, as pointed by Chander (1992) of learning mathematics consists in its providing a structure for organising the experiences of the child. Although the mathematical experience is founded on the physical and the psychological experience yet, it is not identical with them or wholly dependent on them. The chaotic diversity of sensations, which the human mind receives through the various sense organs, would be utterly meaningless without some ordering structure. The various sense organs differ not only qualitatively as to the class of characteristics they can decipher but also with regard to the precision and extent to which they respond to them. Further, the human mind develops a high degree of coordination between these various senses. Mathematics deals with such general and abstract notions as elements belonging to a class, ordering, separating, combining, succession etc. The sensations from the various sense organs can be organised or structured with them. The mathematics relations developed refer no to the particular characteristics of the object but to those operations, which are independent of the nature of any particular object or person doing them.

The constraints put by visual impairment result in restricting the richness and extent of physical experience both as a major precise source of
sensations as well as a factor complementing other sensations. The problems, faced by Children with Visual Handicap in learning mathematics, can be attributed partly to visual impairment but to a great extent to the inappropriate teaching methods and non-availability of learning material. An over insistence on the use of conventional material without adequate adaptation and methods which presume too much from Visually Handicapped result in inadequate understanding of the mathematical concepts, relations and operations.

Introduction of the mathematical concepts need to be hierarchical and the syllabus prescribed should reflect the needs of the learner. Though a common syllabus could be prescribed for the Sighted and the CVH, the content strands should clearly indicate the Substitution, Omission (where necessary), Deletion and Addition (S>O>D>A principle) of alternative content which are not feasible and practical to be taught to CVH. Teachers, can thus focus on the pedagogy rather than making subjective decisions about teaching or omitting a concept.

Diagnostic approach to teaching should be inbuilt in any teaching method/strategy adopted. Error analysis of the performance of CVH students of this study gives in insight into the interventions required. Teachers can design their method based on such information. Task analysis of various concepts to be taught also helps the teacher to identify the approach/method required to teach the concept. Jangira and Rath (1984) have given an example of task analysis with respect to a mathematic task for teaching the blind in integrated setting. This approach to instruction is equally applicable
for teaching CVH in residential setting as well. Primary operations for addition and subtraction of positive numbers upto 9 are to be taught to the class using number-line. The pre-requisites for the children for this task are that they can locate number on numberline, they have acquired the concept of numbers upto 9 and they have also been exposed to the addition and subtraction operations with concrete objects without carrying over and borrowing. The purpose of this learning task is to help the child transfer the experience of adding and subtracting with concrete objects to numbers on the numberline. For addition of numbers on the numberline he should (a) Select the first number on the numberline; (b) count exactly corresponding to the second number on the right of the first number on the numberline and (c) record the number he reaches and write the answer. For instance, in order to add number 3 and 4 (3+4) the child locates number 3 on the numberline, counts 4 on the right hand side of number 3 on the numberline and reaches 7. So the answer is recorded as 7 (3 + 4 = 7). For subtraction, the child (a) locates the first number on the numberline; (b) counts back on the left of the first number corresponding to the second number or from the number to be subtracted; and (c) records the number he reaches and writes the number. For example, to solve 7-4, the child locates 7 on the numberline, counts 4 backward on the left side of the number 7 on the numberline and reaches 3. So the requisite answer is (7-4=3) three. The task analysis can be described in the following manner.
Task Analysis

Reading numbers on the numberline

Indentifying the directions to proceed for the operations

Addition (Right of the first number)

Counting corresponding to the second number

Reading the number reached

Writes answer

Subtraction (Left of the first number)

Counting corresponding to the second number i.e. the number to be subtracted

Reading the number reached

Writes answer

Figure: 8 Task analysis of addition and subtraction using numberline

Instructional Procedures

Considering the task analysis the following instructional objectives can be stated for this learning task:

- After completing the learning task, out of the given 5 sums of addition of two numbers from 1-9 without carry over the child is expected to do all the sums using numberline correctly in 5 minutes.
• At the end of the learning task, given 5 sums of subtraction involving two numbers from 1-9 without borrowing, the child is expected to do all the sums correctly using numberline.

In order to realise the instructional objectives, it is desirable to select instructional procedures for teaching the blind child along with Sighted children in a regular class. The Sighted children will be exposed to numberline on the blackboard and in their note book when the teacher explaining the numberline and location of numbers on it. The additional requirement for the blind child will be an embossed numberline prepared in the resource room. The numbers will be labeled at appropriate places either as embossed numbers or in Braille. When the normal children look at the blackboard as the teacher explains the numberline, the blind child hears and refers to the embossed numberline. The blind child may also be helped in this by his Sighted peers sitting with him. The operations of locating numbers can thus be taught using blackboard for the Sighted children and embossed numberline for the blind children.

"Teaching mathematics is difficult for children with visual limitations" (Mukhopadhyay et al. 1987), however, provided with appropriate training, modified curriculum and availability of resources will not only ensure that teachers being proactive in teaching this area but also learners taking interest in learning as the learning would be more fun than just being a subject area to be learnt and will appreciate the relevance of the learnt concepts in day to day activities.
6.4.3.1 Instructional Aids

Concretised mathematical experiences for a visually handicapped child is to add some tactile features to all the materials – whether demonstrative, instrumental, exploratory or practice materials is narrated. Never to mean that visual features are replaced by the tactual; they have to be added. Adding these features would be advantageous to both – the visually handicapped and the Sighted. The handicapped, the blind child, would be able to perceive and observe the features tactually; for the Sighted children the experience would become enriched as multi-sensory. Moreover, as integrated education for disabled children is to stay, children suffering from various handicaps would be sharing experiences in ordinary schools. To accommodate all – the mentally deficient, the hearing disabled alongwith the visually disabled, multi-sensory materials would suit best for classroom use (Gupta, 1992, p. 256). Efforts require to be initiated in this regard – revolutionising learning through multi-sensory materials.

Further emphasizing on the tactual abilities of the CVH for learning, Gupta (op. cit) remarks that “The whole proposition of teaching visually handicapped children mathematics rests chiefly on exploiting their tactual perception abilities for learning. An understanding of the limitations as well as the capabilities of touch is therefore essential. In contrast to vision, touch is analytic – it conveys to the mind messages regarding form, texture and the relief only progressively, never instantaneously. The span of touch is also shorter than the eye-span. Eye-span covers in general three-four words of print at a time, whereas touch-span covers every single letter separately. Touch-reading or scanning is slower therefore on two counts – one, the span
is out of question. And beyond all that - the primary limitation of perceiving the horizon. Vision extends experiences to the horizons of zenith where the sky appears to meet the earth; touch experiences are limited to the horizons at the lengths of arms alone. Given that too within the reach of arms, a blind child does not 'see' a thing unless he is 'shown' that. Message for the teacher is clear then. It would not suffice to only provide the materials to visually handicapped children; materials have to be shown to them and they have to be encouraged to manipulate the materials. In case of special school settings, teacher-pupil ratio may permit this easily, but not so in the integrated school setting, where classrooms are already over-crowded. In case of the latter, the mathematics teacher has to avail of the services of the special (resource) teacher, but that also may be occasional. One feasible strategy may be pairing the blind child with an accepting and acceptable peer who may 'show' the materials to the handicapped friend. In any class, several peers readily come forward in this respect" (pp. 256-257).

So far as the availability of tactile materials is concerned, several ways are open. Instrumental materials like the tactile scale, compasses or the entire geometric set are commercially available. Three-dimensional models, as stated earlier, are no problems. The real problem lies with the two-dimensional representations, which require 'visualisation', a difficult premise for the visually handicapped. It would be more fruitful if collapsible wire-models of three-dimensional objects are pressed flat on to the surface for initial tactual exploration and thereafter matching diagrams or figures made with thread or wire glued on sheets are presented. Preparing indigenous tactile diagrams and other aids also does not involve much labour. The
mathematical boards – the graph board or the geo-board may be constructed with sheets of plywood or rubber, and may be either perforated or pinned permitting use of thread or wire. But care must be taken that the materials are not so hard or sharp as to hurt the reading fingers since these alone are the greatest learning instrument with the visually handicapped child. Of course, the best course of action would be to prepare raised diagrams.

6.4.3.2 Structuring Mathematical Understanding

Provision for concrete experiences is however a necessary, but not sufficient condition for success in learning mathematics. Beyond those provisions, the teacher has to lead the learners toward accommodation and assimilation of new meanings into their existing structures. Without that, the entire programme collapses no matter how much individualisation planned. National Council of Teachers of Mathematics (NCTM, 2000) commenting on the teaching principle states that "Effective mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well. Students learn mathematics through the experiences that teachers provide. Teachers must know and understand deeply the mathematics they are teaching and understand and be committed to their students as learners of mathematics and as human beings. There is no one "right way" to teach. Nevertheless, much is known about effective mathematics teaching. Selecting and using suitable curricular materials, using appropriate instructional tools and techniques to support learning, and pursuing continuous self-improvement are actions good teachers take every day. The teacher is responsible for creating an intellectual environment in the classroom where serious engagement in mathematical thinking is the norm."
Effective teaching requires deciding what aspects of a task to highlight, how to organize and orchestrate the work of students, what questions to ask students having varied levels of expertise, and how to support students without taking over the process of thinking for them.

Mis-conceptions in mathematics are very common to find in any learner, but the tragedy is that they happen, as Davis (1984) asserts, not because of any ‘cognitive limitation in students’ or ‘time limitation’. Absolutely, their causes lie in inadequate and conflicting teacher education programmes and functionally in the inadequacy of curriculum approaches. Davis (op cit) identified four such deficiencies: (i) "the problem of non-accumulating bits, i.e. "not seeing the forest for the trees", (ii) the problem of superficial verbal approaches, (iii) rote imitation of procedures and (iv) the too slow pace, especially during grades through 8, followed by a hectic cover-up during the secondary school years. And above all, the presentation of maths from a wrong point of view as if it comprises facts and techniques and recipe’s, rather than problems, creativity and reasoning. The only way to check misconceptions occur is to pose questions with analytic mind to puzzle the learners, sometimes even to confuse them to arouse a bit of restlessness for finding the solution. It is the crucial role of the teacher then, to raise questions and queries about the concrete experiences in a manner as leads to the assimilation/accommodation of the new concept in ‘the forest’ of structures (pp. 339-349). From the findings of the study related to curriculum analysis (vide Section 5.5) it is apparent that the emphasis on learning of modalities outweighs the need for understanding the mathematical concepts. Commenting on the Learning Principle, NCTM (2000) reinforces the
mathematical understanding as compared to being proficient with the use of modalities. According to NCTM (2000) "Learning the "basics" is important; however, students who memorize facts or procedures without understanding often are not sure when or how to use what they know. In contrast, conceptual understanding enables students to deal with novel problems and settings. They can solve problems that they have not encountered before. Learning with understanding also helps students become autonomous learners. Students learn more and better when they take control of their own learning. When challenged with appropriately chosen tasks, students can become confident in their ability to tackle difficult problems, eager to figure things out on their own, flexible in exploring mathematical ideas, and willing to persevere when tasks are challenging. Students of all ages bring to mathematics class a considerable knowledge base on which to build. School experiences should not inhibit students' natural inclination to understand by suggesting that mathematics is a body of knowledge that can be mastered only by a few.

The order of complexity of arrangement of materials should be conducive to a sequential learning of the concepts. Manipulative objects should be designed to appeal to a child's senses: they should be amenable to be touched and not fragile. Such materials will provide concretised experiences for a child to learn concepts. In order of gradation of concepts various materials and tool kits can be designed that are equally useful for CVH and the Sighted. However, with any instructional media, presentation of items will need to be modified to suit the needs of the learners. Procedures for adapting the instructional media for kinaesthetic/tactile learners have been listed by Thornton & Toohey, (1985).
For the modalities that are specifically designed to be used for CVH, teachers should proceed slowly, introduce different modalities and should relate to other modalities in terms of its advantages, in this way the child will not feel burdened by too many modalities. Curiosity to explore the modalities and how best the child can use it should be the primary aim of introducing the various modalities. For example in introducing the Taylor Frame as a modality to learn mathematics, teachers should sequence the introduction by slowly progressing from the perception of the Taylor Frame moving to the perception of the ‘types’ with its two different embossed ends, thus training the fingers to perceive the various notations of the embossed ends when kept in the Taylor Frame hole in a particular direction. Gupta (1992) comments on the preference of Taylor Frame for learning mathematics as “teachers favor consistent use of Taylor Frame from the earliest day to help fingers develop the discipline of mathematics. Further, The Taylor Frame permits writing mathematical steps in the manner they are written in print” (p. 263).

Fostering mathematical understanding requires the recognition of general errors and also the alternate strategies to teach the mathematical concepts to the CVH so that irrespective of the modality the understanding of the concept happens. General errors that are observed while learning the use of Taylor Frame is in representing the numbers that are formed by the reverse end of a ‘Type’ for e.g.: placement of 2 and 0 is confused as with the direction of placing the ‘Type’ in the slate remaining the same, the embossed end of the ‘Type’ is reversed. Some children exhibit problems in remembering to reverse the embossed ends while other have perceptual confusion. Activity
method with heuristic approach for teaching the perceptual confusion of 'Type' ends for 0, 9, could be as shown below:

Eg: used by teachers for the Sighted to help the child exhibiting reversal problem with numbers – 6 and 9

Above example can be adopted by the teacher for CVH on Taylor's Frame with the types as shown in the figure 9. This will not only help the child to register differences between the numbers 0 and 2 but also help in exploring the numbers in column, rows and diagonally.

Figure: 9  Perceptual understanding of the different embossed end of a 'Type'

Further in order to teach the concept of place value various concrete activities can be introduced for eg: Beads and string of beads. One string of beads could be made of 10 beads so that when a child is asked to pick beads for the number 34, the child would pick up three strings of beads and 4 separate beads. This exercise has been tried out on Sighted children to split numbers as reported in the Teachers’ reflections on Primary School Mathematics. When children are taught through approaches that are uninteresting and do not involve them in creating solutions children lose
interest in the subject which in turn blunt their capacities to learn. Hence, it is essential to adopt concrete-exploratory activities for introducing and strengthening the basic arithmetic concepts.

Beginning at a simple level the pupils should be lead into the mastery of different ways of recording and representing mathematical problems and their solutions through increasingly complex stages. The attempts at recording should be introduced gradually as the idea of pattern and relationship develops, so that what is symbolised is understood, and the whole process of developing mathematical concepts is tied in with the vital activity. As experience and understanding increase, more formal and more abstract work can be introduced, with problems posed, and solutions worked out with a decreasing need to refer back to concrete examples. Apart from subject knowledge 'pedagogical content knowledge' is believed to be the most essential element required for expert teaching. Marcucci (1980) commenting on the Math instruction for Sighted classified instructional techniques into four types (a) modelling, or the use of visual aid manipulative or models to illustrate relationships in a problem; (b) systematic instruction emphasising a prescriptive approach to problem solving; (c) guided discovery, in which questions are used to guide a student to discover the solutions to a problem; and (d) heuristic instruction stressing the teaching of general problem solving skills, such as simplifying a problem through the use of fewer variables or smaller numbers. Marcucci (op cit) concluded that, art the elementary school level, where the clearest conclusions could be drawn; the heuristic approach was the most effective. The systematic approach produced a slightly positive effect while modeling and guided discovery fared no better than techniques
used under the control conditions. Keeping in mind the techniques advocated by Marcucci (op cit), instruction of mathematics to the Children With Visual Handicap needs to be concretized using non-visual aids and experiences such that modeling, problem-solving and guided discovery may require successive modification or organization of learning material or aids but the purpose is to enable the children to comprehend the structure of mathematical forms by leading him through situations of increasing degree of complexity" (Chander, 1992, p. 245). Thus, it is seen that appropriate use of instructional aids can help CVH in acquiring mathematical concepts better than in the absence of such facilities.

6.4.3.3 Student involvement in learning

Involvement of students in learning is a significant factor contributing to the achievement of instructional process for any subject area. Involvement of CVH in any instructional process becomes further more crucial as they not only have to adjust themselves to the pedagogy of subject matter but also to the residential setting wherein demand for learning basic living skills including mobility training is focused much before they are directed to any formal instruction of a subject matter. Repeated visits to the institution is lieu of collecting data by building rapport with the child, it was observed that in many instances children were not motivated to learn certain subject matter owing to repeated failure in learning the concepts. Mathematics is one such areas which is dreaded by the student. They like the subject till the stage when they are practicing the numbers orally and as soon as modalities are introduced for higher learning, not all students show inclination to learn new methods further, the perceptual qualities of the modalities does not offer equal level of
manipulation for all students. For eg: Taylor Frame calls for good finger
dexterity. A class of CVH being highly heterogenous with varying abilities
including motor skills, all students do not show interest in pursuing
mathematics using Taylor Frame as a modality to learn. Complexity with
modality is further added by introducing Nemeth Code which is different from
the regular braille code. Hence, new learning at each stage for same subject
matter for the mere purpose of recording and reproduction creates stress
among CVH and make them lose interest in the subject matter.

From their review of the motivation literature, Adelman and L. Taylor
(1983) list tactics for enhancing intrinsic motivation, including the following:

- Provide some choices in curriculum content and procedures to enhance
  the student’s perception that learning is worthwhile, and discuss the
  relevance (real-life applications) of various content.
- Through discussion, obtain a commitment to options that the student
  values and indicates a desire to pursue. Contractual agreements are
  helpful
- Schedule informal and formal conferences with the student to enhance her
  or his role in making choices and negotiating agreements
- Provide feedback that conveys student progress. The student must not
  perceive the feedback as an effort to entice or control. Self – correcting
  materials are useful (p.530).

Another dimension that may be included in efforts to promote student
motivation relates to the beliefs that students have about themselves. Many
students do not believe that they can learn or change. Ellis, Deshler, Lenz, Schumaker, and Clark (1991) present four techniques for teachers to use to help students after their beliefs about their learning and performance:

- Engineer instructional arrangements to promote and reinforce student independence.
- Communicate high expectations for students through words and actions
- Help students identify and analyse beliefs that underlie their behaviour as ineffective learners
- Help students discard unproductive beliefs through a variety of activities and interactions (p.530-531).

The above models could be adopted for boosting self motivating and involving CVH in designing their individualised program for learning basic arithmetic skills. Thus, involving the child at all stages of learning from choosing the content and methodology to the type of learning strategy that can be adopted. Practical applicability of such models will reval their advantages and help in improving the education for CVH. And the modality which the child likes should be available to the child all the time to practice on it whenever needed by the child rather than locking away and making it available only during the instructional process.

6.4.4 Implications for teacher training

Many experienced and accomplished teachers feel, with good reason, that their approach to teaching mathematics has served children well. Their only comments are on certain modalities that are being used specifically
Taylor's Frame. Hence, there is little motivation among teachers to re-think about the curricular content, teaching – assessment pedagogy or even about improvising the materials on their own. They feel that they are overwhelmed with the heterogeneity in the classroom and hence cannot focus on other aspects of curriculum. Understandably, it is the role of curriculum planners who need to consider these factors and restructure the curriculum as per the special needs of the learner. Involvement of teachers and students play a crucial role in such an exercise. As an outcome of the restructuring of the curriculum, many teachers will need to take risk and move out of their comfort zone, and anticipate the need of refinement and revision. Many teachers need to be encouraged to begin slowly for instance to change only one thing at a time. There is a great need for support structures within schools that will enable teachers to try new approaches, share their experiences with one another, enjoy parental understanding and support and cope with student expectations.

The process of reviewing and rethinking the curriculum is essential to change, and is an evolutionary and ongoing activity in situations where there is a strong orientation to change. The four cornerstones (NCTM, 2000) supporting the central goal of mathematics reform that is applicable to mathematics curriculum reform for CVH are:
As emphasised in the National Curriculum Framework for School Education, India 2000 regarding the preparation of innovative instructional packages states that detailed curricular guidelines and model syllabi in all the subject areas will have to be developed along with the coverage in each subject area, its depth and treatment for each stage and grade, keeping in view the learning outcomes to be attained by the learners. The scheme of studies must ensure equitable importance to the scholastic as well as co-scholastic areas. This has to be followed by development, production and introduction of packages of curricular materials for Sighted and adaptations need to be made where necessary for CVH.

A major change in the approach, planning, preparation, production and distribution of all the teaching-learning and training orientation materials is the first requisite for any significant improvement in curriculum transaction. Competency-based and process oriented materials to facilitate joyful self-learning and self-directed learning experiences in both the formal and the alternative education modes will have to be developed. There has to be a
complete modular package of textbooks, workbooks, teachers' handbooks and multimedia materials. These materials must respond to contemporary concerns, approaches and thinking at all the stages of school education. From the current study, it is observed from discussion with teachers that in mathematics teaching for CVH, providing braille textbook for mathematics is not sufficient, production of braille and textbooks for teaching mathematics with suitable adaptations for CVH and a comprehensive manual to guide the teachers in using the textbook is warranted.

Professional development for teachers and administrators can complement further the curriculum review and reform efforts. Discussion with the teachers and administrators of the special schools visited disclose that very few in-service training programs are available for teachers and workshops are very rare. Even Pre-service training was not mandatory when the teachers had joined the school long time back, hence, not all teachers are professionally trained to teach CVH. However with recent publication of the Persons with Disabilities Act (1995), RCI has taken initiative to provide training at diploma level for all teachers of special schools among which training for teachers of children with hearing impaired is comparatively more than for teachers of children with visual impairment.

Again, National Curriculum Framework for School Education, India (2000, 2005) regarding the Teacher Preparation Programmes emphasise that the pre-service teacher preparation curriculum will have to be reviewed and re-oriented at and despite its having been revised recently, new concerns and issues will have to be incorporated therein. This would take some pressures
off the in-service teacher education programmes later. Pre-service and in-
service education is stipulated to be inseparable and continuity between the
two has to be maintained. In the pre-service teacher preparation programmes
adequate emphasis on the content knowledge of different subject areas and
proper integration of methods of teaching with the content of school subjects
and a strong component of ‘Evaluation’ will have to be ensured. Besides,
understandings and competencies relating to different elements of curriculum
development will have to be specially included in these programmes in both
theoretical instruction and practical training.

However, continuing education of in-service teachers needs attention
because all their initial education and training may not remain relevant and
effective because of the present rate of change in content and pedagogy in
the national and world scenario. Teachers have to be sensitized about the
new curricular concerns, issues and transactional approaches. For this, print
materials in simple, jargon free languages of the region and also audio-video
materials need to be developed and disseminated through direct and distance
modes. The in-service training shall not be just a one time affair but shall have
to be run on a sustained and regular basis. A cascade model of training key
resource persons and resource persons can be followed and a collaborative
mechanism for this purpose may have to be evolved among the various
national, state and district level agencies. Teleconferencing as an effective
strategy of providing training to the teachers may also be profitably utilised.
Maheswari (1998) commenting on the implications of an experiment
conducted by National Council of Education Research and Training (NCERT)
on using teleconferencing as a technique to train teachers comments that
increasing use of satellite communication and information technology in teaching-learning processes and in inservice education of teachers is becoming a reality. The use of interactive video technology holds far reaching promise for improving classroom processes and inservice education of teachers, especially in the context of developing countries such as India, Pakistan, Bangladesh and Sri Lanka where the number of teachers to be provided recurrent training is very large.

Thus, in order to effectively implement a well-designed curriculum it is essential that regular inservice-training is provided to the teachers of visual handicap.

6.4.5 Implications for development of cognitive capabilities among CVH

The results of the present study on development of cognitive capabilities are sufficient to warrant serious considerations for educational implications of CVH. A marked degree of developmental lag in their cognitive development indicates the drawbacks of the present primary school curriculum for CVH. Their developmental lag may be due to the lack of suitable, adequate opportunities to explore and experience the interaction with the physical environment but not necessarily inherent in their visual impairment. The following implications are suggested:

- The primary school programme as it is organised at present for CVH in both private and Government special schools for the blind does not cater to cognitive development in pupils leading to a marked developmental lag in them. Hence, the objectives of primary stages have to be refined to
bring into focus cognitive development among other aspects of development.

- A variety of structured activities for active manipulation of things leading to new perceptions and mental operations are vital for developing specific cognitive structures leading to their overall cognitive development. Such programmes, purposefully designed to foster cognitive development can cater to children with different degrees of visual handicap, studying in different institutions and children of both sexes.

- From this study, concept of place value among CVH is observed as poorly developed. Hence, suitable cognitive activities related to counting, seriation is required to build on the concept of place value. Concrete and semi-concrete activities designed to foster learning of place value not only helps the CVH but may be used for the Sighted in the regular class. Mercer and Mercer (1998) emphasising on the use of Concrete-semiconcrete-abstract method of teaching maths to children suggests an example of semi-concrete method of teaching the concept of place value:
  
  To begin place value instruction at the concrete level, gather two plastic cups, a bundle of straws, and a set of blocks. Set the two cups on poster board, label the right *ones* and the left one *tens*. Tell the student to count the blocks. For each block the student counts, place a straw in the ones cup. Stop when nine blocks are counted and nine straws are in ones cup. Before picking up the tenth straw, explain that one straw in the tens cup represents ten objects. The student then takes the nine straws out of the ones cup and places one straw in the tens cup. Next, the student continues to count the bloakcs and place the straws. Counting proceeds in
the following manner 1 ten and 1, 1 ten and 2, and so on. Each time a ten is reached empty the ones cup and place a straw in the tens cup. Although the student is told that 1 ten and 1 is another name for eleven, and 3 tens 5 ones is another name for 35, during place value instruction encourage the student to count using 3 tens and 5 system (p. 481). From such concretised experiences to using symbols in Taylor Frame to represent place value the concept should be developed by the teacher slowly and gradually.

- Conservation tasks of the study yielded results that showed the emergence of Conservation of Number somewhat earlier than the Conservation of Quantity. Piaget (1965) considers the concept of conservation fundamental to later numerical reasoning. Hence, suitable activities to foster conservation (quantity and number) should be designed and taught to children at lower primary grades. Textbooks for various grades could include activities that promotes concept of conservation.

Research on cognitive representations of numbers and cognitive analysis of problems of comprehension in mathematics informs the educational practitioners of the needed curriculum enrichment from a constructivist perspective (Duval, 2006). Such enrichment and suitable adaptation for CVH may foster cognitive understanding of arithmetic.
6.5 SUGGESTIONS FOR FURTHER RESEARCH

- Studies should be conducted for CVH in different education set up (Special Schools versus Schools with integrated Education Programmes) so that the comparative analysis between the Sighted and the CVH would be understood better.

- Surveys at district/state/national level on the development of arithmetic competencies among CVH should be undertaken to develop suitable prescriptive curriculum for them.

- Arithmetic Diagnostic test development should be considered seriously and standardisation could be aimed at higher order arithmetic competencies.

- Studies on grade-wise development of arithmetic skills with a longitudinal approach could provide a better picture of developmental aspects of arithmetic competencies among CVH.

- A detailed analysis of instructional aids used for arithmetic teaching should be taken up to suggest the advantages and disadvantages of different types of teaching learning aids.

- Suitable remedial packages could be developed for both Sighted and CVH and experimental studies should be conducted to find the effectiveness of such packages in different school set-up (Special Schools versus Schools with integrated Education Programmes).

- Studies on development of cognitive capabilities in relation to arithmetic achievement should be conducted so that thinking skills that are common
to both cognitive development and arithmetic skill development could be identified and remedial programmes can be developed on that basis.

- Studies on cognitive arithmetic among the CVH will provide insight into the mental representations of numbers and its operations in absence of vision. Such results may be useful in determining activities to promote arithmetic concept development among the CVH.

- Studies on learning models (name them) may be useful in determining the assessment strategies that may be used for assessing the acquisition of arithmetic skills among the CVH.

- In-depth research on the types of errors committed by CVH on arithmetic tasks may yield educational implications for developing individualised education plans to address the deficits in learning of arithmetic.

- Age-wise and grade-wise analysis in an indepth study of CVH would yield clear cut evidence of the development of cognitive stages in relation to academic achievement in general and arithmetic achievement in particular among CVH.

- Longitudinal study to investigate the effectiveness of fostering certain cognitive capabilities (e.g. seriation, conservation) on the development of number operations may yield results worth considering for re-orienting the content strand at the basic level of teaching mathematics.

- More of qualitative studies on the emotional development of CVH would definitely provide for analysis of their lack of motivation towards learning arithmetic.
• Studies on teacher training – in all its essential details should be considered for both the regular as well as special schools that will provide for improving teacher effectiveness.

• Inquiry into the effectiveness of inclusive practices for CVH in the regular school setting may yield results to help educators prepare CVH studying in special schools for attending regular schools with inclusive programmes.