

CHAPTER II

EMPIRICAL EVIDENCES

2.0 Introduction

The previous chapter describes the Piagetian cognitive development model and discusses the possibility of 'inducing' cognitive development (within certain limits) as a theoretical proposition. What is presented in this chapter is an empirical support to this proposition in the form of a review of research reports. An exhaustive survey of related studies is not attempted as there are umpteen studies. Instead, a few exemplars are chosen to show a trend in the evolution of 'acceleration studies' (though not in a chronological order), with a view to deriving certain principles for the development of a classroom instructional model which would aid cognitive development. The studies reviewed in this chapter are broadly classified into two classes viz., 1) studies conducted abroad and 2) studies on Indian population. In the latter class all types of Piagetian studies are included to indicate the status of researches related to a Piagetian framework in India.

2.1. Effect of Structured Experiences on Reasoning

In the '50s and '60s, a number of investigators tried to induce Piagetian concepts under laboratory conditions. These attempts were largely unsuccessful (Goldschmid, 1971

p.104). Flavell (1963), has reviewed these early efforts and concluded that "Piagetian concepts have so far proved inordinately difficult to stamp in, whatever the training procedure used" (p.378). But, if one closely examines these studies reviewed one can find that the training procedures used were more or less "perfect roads to learning". That is, the learning sequences are arranged in a perfectly logical manner (according to the logic of the one who frames these sequences and not according to the logic of the learners). Several attempts were made by researchers in the '70s also but, they met with little success. Noss and Raven (1973), studied the effect of structured learning sequences on the reasoning of V, VII and IX graders. They report that only a few of the IX graders could benefit from the training and none from the V or the VII. They attribute the difference to the reasoning abilities of the students before training. Hammon and Raven (1973), report that only a few among grade VIII students who were capable of formal reasoning could improve their reasoning through structured learning sequences. Hall (1973), attempted to improve the conservation ability in the VI and VII graders through six months of teaching elementary chemistry using programmed instructional material. He found that they did not attain conservation of chemical identity in spite of prolonged treatment. Walker (1979), tried to study the effect of readymade learning kit

on genetics on Piagetian cognitive development in college students. An 'unexpected finding' of the study is that the ability of students to operate at formal level is not related to the learning of problems. Lehman(1980) failed to aid the cognitive development through an audio-tutorial instructional strategy, though the individual was the focus of the instruction. Levine and Linn (1977); and Linn(1980a), reviewing studies conducted to improve reasoning through structured learning sequences in science and mathematics related concepts mention that these studies could produce only very limited success. They mention that such structured sequences may be beneficial to those who already show signs of formal reasoning and not to the concrete operational learners. The above statement is supported by a few empirical evidences. Biran constructed a successful learning programme which demonstrated the designing of experiments, the testing of hypotheses and the drawing of conclusions, Grey found that adolescents, subjected to programmed texts for training judgement, obtained higher scores on thinking problems. Anderson administered instruction in thinking to pupils and the results showed considerable influence on the maturity of judgement. Stones gave programmed instruction in relevant historical concepts and increased the maturity of historical judgement in a group of secondary pupils (Modgil and Modgil, 1976 p.177). A few observations that could be made regarding these four studies, which differentiate them from the studies

reported earlier, are; 1) these programmes have incorporated an element of discovery 2) they were problem oriented and 3) these programmes were presented to learners who had shown signs of formal operational reasoning. Linn (1980c), comments on the failure of instructional strategies by saying that students do not get a clear idea as to how they can use the learnt strategies to new problems since the problems given in the strategies are not formulated by them. Rather these problems are presented to them. Linn (1982), on reviewing a few more studies mention that instruction which combines strategy training with application training succeeds more consistently than either by itself. Linn and Thier(1975) and Linn (1980b, 1980c), suggest that success can be obtained better with instructional interactions involving effective diagnosis of the inaccurate rules used by the students. Lehman(1980) attributes lack of flexibility in the strategies to the poor performance of students in reasoning tests.

The failure (mostly) of adolescent students to improve their reasoning with these structured instructional strategies shows the importance and need of 'active participation' (in the cognitive sense of the term) on the part of the students in order to develop their cognitive structures or reasoning patterns. Prestructured problems may not appeal as problems to the students. The findings are in agreement with the theoretical contention by Piaget that 'to know an object is

to act on it - to modify it, to transform it, to understand the process of transformation and in turn to understand the way it is constructed. Operation is the essence of knowledge - an interiorised action which modifies the object of knowledge. Operation is interiorised but reversible action. This does not occur in isolation but as part of the total structure with logical interlinks. These operational structures are the basis of knowledge' (Piaget, 1964 p.181). Prescribed problems may remain isolated from the learner's cognitive structure unless he acts on it and the problem occurs as a hurdle in the way of explaining a phenomenon. The problem designers frame the problems according to their cognitive structures which are not likely to appeal as problems to the learners, since the problem designers have made no attempt to understand the cognitive structures of the learner. About the difficulty in one individual organising experiences for another, Dall (1972) says, "there is a strong temptation to assume that presenting subject matter in its perfected form provided a royal road to learning. This is the difficulty with programmed instruction, or even with text book instruction. However, there is also another temptation for all goal oriented educators, and that is to assume that the psychological organisation can be done, or made more efficient, if one individual does it for another. But the very nature of the concept requires that the individual does his own organising. Not only is there no royal road to

learning, neither are there maps which the individual must merely memorise".

2.2 Previous Knowledge on Learning

The failure of structured learning sequences in effecting cognitive modifications may be attributed to different reasons. For instance, prescriptive problems do not appeal as problems to the students, as they do not get the opportunity to organise the structure of concepts. Rather it is already organised for them. This indicates the need for understanding the cognitive structures of the learners' prior to instruction. In this context, an observation on Ausubel's theory is of relevance. 'If I had to reduce all the educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly' Ausubel (1968).

Posner et. al.(1982), stress the importance of using students prior knowledge in developing learning strategies. They developed a model of learning where learning is not simply an addition of bits of information, but involves the interaction of new knowledge with the existing knowledge. They report a little success in developing cognitive structures using this model. Hewson and Hewson(1983), using the same model of strategy development conducted an

experiment which reveals that learning strategies developed on the prior knowledge of students aided cognitive development whereas strategies developed without considering the prior knowledge of students failed to do so. Pines(1978), developed an audio-tutorial instructional package in science concepts based on the prior knowledge of learners. On studying the relationship between prior knowledge and the development of cognitive structures he reports that, relationships exist between prior knowledge and resulting cognitive structures subsequent to instruction because relevant cognitive structures affect learning. Others who report similar findings are: Wesney(1978) and Schwartz(1980).

2.3 Existing Structures Influence Development

Piaget calls his developmental epistemology "naturalist but not positivist". Cognitive behaviour is an outward sign of the assimilatory and accommodatory capacities of a living organism. The biological aspect of Piaget's theory is often difficult to grasp for those psychologists who believe that mental development is infinitely malleable under favourable conditions and with adequate teaching methods, and who are convinced that what they think of as errors of growth can easily be corrected. A biologically inspired theory that uses concepts such as assimilation, accommodation, and action schemes is very different from a learning theory that tries to account for cognitive development in terms of

associations, connections, and conditioning. The latter type of mechanism always suppose that two events are linked in the subject's mind because he has passively submitted to an outside pressure connecting the two. The concept of assimilation, by contrast, supposes that the subject actively assimilates a new event to already existing structures. There is thus an interaction between the knowing subject and the objects that are to be known. As knowledge of these objects proceeds, the subject's activity becomes better and better organised. This justifies Piaget's theoretical distinction between two types of knowledge: logico-mathematical knowledge and the knowledge of the physical world. "From the Piagetian point of view, these types of knowledge are the result, on the one hand, of the organisation of the subject's activities (logico-mathematical knowledge resulting from reflective abstraction) and, on the other hand, of the knowledge the subject gains about the object's properties (knowledge of the physical world resulting from physical abstraction)" (Inhelder, 1977 p.54).

The above discussion clearly indicates the importance of logico-mathematical knowledge in addition to the knowledge of the physical world in the construction of cognitive structures. How the dialectical relationship between these two knowledge structures influences the cognitive development

is brought out through the following empirical evidences and many others discussed in the sections to follow.

Nurrenbern (1980), investigating the problem solving behaviour of concrete and formal operational high school chemistry students, reports that formal operational students approach the problem differently from concrete operational students. The formal operational students are able to reshape the problem and derive more meaning out of it whereas concrete operational students fail to do so. Morin (1978) also reports similar findings after investigating the problem solving abilities of different students using problems requiring formal thinking abilities. Barber (1980) studying the relationship of differential treatments with concrete and formal biology concepts using concrete and formal language on the cognitive development of concrete and formal operational students, reports that concrete operational students could construct concrete concepts when taught through concrete language whereas they fail to construct formal concepts either through formal or concrete language. But, formal operational students benefited from both the treatments. Hayes (1980), studied the effect of two methods of instruction in the achievement of formal and concrete operational thinkers and reports that the teaching methods did not make any difference to the concrete and formal operational students. He mentions that the cognitive level of the learner and the suitability of the conceptual level

of the material to be learnt seem to be important factors rather than the mode of instruction. Besmajian(1978), gave an audio-tutorial package to the concrete as well as the formal learners and found that the formal learners gained better from the package. He attributes the difference to the difference in the cognitive capabilities between concrete and formal learners. Pastore(1976), gave differential treatment to early concrete operational and early formal operational students. Concrete organisers were presented to concrete learners and formal organisers to formal learners. He reports that concrete learners having received concrete organisers performed at a higher level than those who received formal organisers and early formal students performed better having received abstract organisers. The above studies clearly indicate that a minimum of development of the logico-mathematical structures are required for the assimilation of abstract concepts or for the construction of abstract structures.

2.4 Role of Manipulation of Objects on Cognitive Development

The equilibration model of Piaget clearly indicates the importance of 'acting upon' objects and ideas. Researchers who attempted to show differential effects for concrete and formal students with the manipulation of models are Sheehan (1970) and Goodstein and Howe(1978). Sheehan found that manipulation of models was beneficial for both concrete and

formal thinkers whereas Goodstein and Howe found that only the formal students benefited from manipulation. Gabel and Sherwood (1980) hypothesised that prolonged manipulation of models might develop the reasoning of concrete students. He taught chemical concepts to high school children by allowing them to manipulate objects for almost one year and found that concrete and formal students benefited. Cantu and Herron (1978), identified concrete and formal operational students. they found that concretisation of concepts helps both types of learners.

The above mentioned studies support the theoretical contention that concrete operational learners may fail to deduce propositional generalisations out of the manipulation with concrete objects, though they may be successful in making concrete generalisations. In order to help concrete learners the concretisation of data might have to be done in such a way that the data presented conflicts with their cognitive structures. Several such attempts at creating cognitive conflicts might initiate changes in the cognitive structures of such learners to resolve their conflicts and discover a new rule. The newly transformed cognitive structure may be able to assimilate the new set of observations better. The above mentioned studies do not report such discoveries by the students except, perhaps, by Gabel and Sherwood where the discovery is more due to

prolonged treatment rather than the manner in which data was supplied to the learners.

2.5 Discovery Learning on the Development of Reasoning

Discovery learning is one of the most widely used techniques to improve reasoning. A wide variety of discovery techniques are used by different researchers, ranging from discovery through prescriptive problems, guided discovery, to pure discovery where the learner frames problems on his own and goes on solving them on his own. From an instructional point of view two types of problems are used in discovery learning by researchers viz., 1) using puzzles or riddles to be solved by the learners (Beasley, 1979) and 2) where problems related to classroom instruction are used.

Rodriguez and Lovell (1983), tried to improve the classification ability and science vocabulary in grade III children using an enquiry approach to teaching and found that through such instruction learners improve their classification ability as well as their science vocabulary. Other studies which report similar findings are Salib(1979) who reports discovery better than expository in accelerating reasoning and Bachuroff (1980) who reports that inquiry based laboratory investigation enhanced the cognitive development of learners.

Cheroenpit (1979), taught concrete and formal

operational students using enquiry and traditional methods. The design of the study was a 2X2 factorial design. He found no difference between traditional and enquiry approach. A similar study is reported by Schneider and Renner (1980) where they compare enquiry approach to exposition. They taught four physics units to two groups of IX graders, (80% of them concrete operational) using the differential treatments and found that there was no significant difference between the two groups in achievement and intellectual development. Blake and Nordland (1978), found no development in a sample of college freshmen who were taught through enquiry approach. Other studies which report similar findings are: 1) Bock (1980), who reports no difference between traditional laboratory approach to teaching and enquiry laboratory approach to teaching; 2) Johnston (1980) who reports that enquiry is suitable only to those students who are capable of formal reasoning; and 3) Wise (1979) who reports that only formal operational students could discover rules of formal nature. Wolfinger (1979), tried to train young children (III and IV graders) on physical causality using science teaching with a discovery approach and he failed. The failure is attributed to the lack of development of proper cognitive structures in the learners. But, Gann (1980) could develop 'physical causality' in IV graders. The success is attributed to students themselves framing

hypotheses and testing them. Abdullah and Lowell(1981), succeeded in making 5-6 year olds make concrete generalisations about 'insect' and 'animals' using coloured pictures and models.

The two groups of studies discussed above seem to display a contradictory picture regarding the effectiveness of 'enquiry approach' in the development of cognitive structures. But, if one closely examines these studies, they indicate that a mere discovery approach to instruction may not aid cognitive development as hypothesised by many. This is mainly because of the lack of 'appeal' the prescribed problems have to the cognitive structures of the learners'. In other words, the prescribed problems may not appear as 'problems' (in the cognitive sense of the term) at all to the learners who have not acted on the information provided to derive a problem. Still, through a prescribed route of finding results they may succeed in finding solutions. But, the process of tackling a problem on finding alternate solutions and testing them remains alien to their cognitive structures. Mayer(1983), reviewing discovery learning literature on science-oriented learning tasks reveals that, 'discovery sometimes resulted in high performance and sometimes seemed to fail. Pure discovery does not take care of the previous knowledge - guided discovery is better. There is a clear and consistent evidence for the superiority of

guided discovery procedures' (p.226). In order to aid development the problems will have to emerge as problems or hurdles when the learner tries to explain a certain set of data by acting upon the data with his cognitive structure. The above statement is supported by the study conducted by Bady(1979a). He says that previous researches show that high school students even after training fail to understand hypothetico-deduction. He encouraged IX graders to formulate hypotheses to problems and test these hypotheses at their own speed and will and reports that cognitive development occurred. That is, they developed their combinatorial reasoning ability to a formal operational level through this hypothetico-deduction exercises. Bady(1979b), shows how the ability to test hypotheses can be developed in high school students by posing problems that suit the cognitive structures of the learners'.

2.6. Creating Cognitive Conflict as a Means of Cognitive Development

Cognitive conflict arises when a learner comes across an information which creates a dissonance with his previously held notion or assumption. There can be three possibilities when a learner comes across such an information 1) it is rejected as invalid, 2) the existing cognitive structure is stretched to assimilate the contradictory information (here the cognitive structure is not modified to accommodate the

conflicting data) and 3) there arises a need to transform his cognitive structure whereby he can accommodate the new information. By the third alternative the cognitive structure develops state of lower equilibrium to that of a higher one. The second alternative gives scope for creating further cognitive conflicts because the 'stretched cognitive structures' are unstable and are more prone to development than the cases where the learners offer the first alternative to conflicting information.

Cognitive conflict was used by Gruen(1965) to develop conservation of number in children of the age range 5-6 years with success. Smedslund (1961a, 1961b) succeeded in developing conservation of substance and weight in children between the age range five years six months, and six years six months using a cognitive conflicting treatment. Mermelstien and Mayer (1969) used similar instructional situations to develop conservation ability like conservation of number, length and area to children of different age groups with success. Inhelder and Sinclair(1969) developed a strategy for inducing cognitive conflicts. Strauss(1972) used this strategy for developing the concept of 'animism' in young children of the age range seven to eight years. He could develop the concept in them. Bredderman(1973) used a similar strategy of teaching to develop the ability to control variables among young adolescent children with success. Other studies which report

similar findings using cognitive conflict strategy are Inhelder et. al. (1974); Karmiloff-Smith & Inhelder (1974); Strauss and Ilan (1975); Murray et. al. (1977); Snyder and Feldman (1977); and Johnson and Howe (1978).

Almost all the above mentioned studies were conducted under laboratory conditions and the individual children were given training alone or in small groups of two or three. The question of whether such a strategy could be used in a group instructional situation was asked by Rowell and Dawson (1981). The questions they raised in their study were 1) can cognitive conflict strategy accelerate conservation abilities? 2) does learning result from classroom presentation? 3) does pretest affect further learning? They tried to develop volume conservation in VIII grade students of Australia and found that acceleration is possible even through group instruction using cognitive conflict strategy.

Bass and Montague(1972), Case and Fry (1973), Lawson et. al. (1975), and Nours and Raven (1973) employed a variety of training methods. Those which were successful in their attempts shared several common characteristics. The first common characteristic is physical interaction i.e., subjects manipulating physical objects or at least viewing demonstrations. The second common characteristic is peer interaction used to induce cognitive conflicts. This is what Piaget calls 'social transmission'. Peer interaction seems to

function by introducing the subject to ideas or hypotheses which are different from their own, thus producing a cognitive conflict. This conflict would promote cognitive development through the process of equilibration or self regulation. Gabel and Sherwood (1980), and Howe and Durr (1982), used peer interaction to induce cognitive conflict. The peer interaction is designed to induce the child to question the premises or assumption upon which he based a premise, judgement or cohesion. They report that the peer interaction is useful even in the middle school level. Both these studies report acceleration of concepts as well as reasoning. Atkin and Karplus (1962) and Lawson and Renner (1975), developed a classroom instruction model called 'learning cycles'. This model divides instruction into three phases: 1) exploration 2) invention and 3) discovery (application). During the exploration phase, the student manipulates physical material provided in the experiment. He is asked to manipulate certain variables in the experiment and observe and record the results. During this period, the student will encounter new information which is not directly assimilable. Through the process of self regulation, existing structures will be altered (accommodation) to allow assimilation to occur. The cognitive conflict which initiates the self regulation process can occur through direct observation of physical phenomena or through social interaction (student-student or instructor-

student). Cognitive conflict and social interaction are not limited to the exploration phase, but can be employed during all three phases. At some point during the exploration phase, the student is asked to try to order the information he has collected into some useful pattern. If the student is unable to devise a method of ordering the information, the instructor may suggest one, but only after the student has made initial attempt. If appropriate, the instructor may also furnish a label for the newly invented concept. These activities constitute the invention phase. To further strengthen the students' grasp of the new concept, he is asked to apply it to new situations in an attempt to discover its usefulness and limitations. This is the discovery phase. The underlying construct of the learning cycle is that through a series of successive equilibrations the student will develop a more refined cognitive structure (Karplus, 1977 p.172). Karplus refers to the three phases as exploration, concept introduction and concept application which seems to define the functions and properties of each phase more clearly.

Studies by McKinnon and Renner (1971) and Smith and Von Egerene (1977), found that by using the 'learning cycle' strategy to instruction one could accelerate concrete students to think more abstractly and therefore transform from concrete to the formal operational stage. In these studies the reasoning

patterns accelerated are 1) controlling of variables, 2) propositional reasoning, 3) combinatorial reasoning and 4) hypothetico deduction. Ward used the 'learning cycle' in teaching chemistry to high school students and found that formal operational students show higher achievement on items requiring concrete thought than concrete operational students. They out performed in the formal items also. Many concrete operational students showed improvement though formal students out performed them. Ward (1979), used the same strategy on 208 students of the chemistry graduate course and found that peer interaction helped in accelerating concrete operational students to formal.

Wollman and Chen (1982), developed a classroom approach of social interaction. This approach comprises of four phases: a) asking pupils why something happened b) asking for a justification c) suggesting an alternative explanation with evidences and d) accepting an alternative only after ruling out all other possible explanations. They compared such an approach of instruction to personalised instruction on II graders in an effort to accelerate the ability to control variables. They report that, the effect of 'social instruction' treatment was quite substantial in comparison with the effects of personalised instruction.

2.7 Acceleration of Mental Operations

The previous section of this chapter (section 2.6) discusses at least three models of instruction that were used by different researchers for accelerating logical operations in learners. They are: 1) 'cognitive conflict' strategy developed by Inhelder and Sinclair (1969); 2) 'learning cycles' developed by Atkin and Karplus (1962) and Lawson and Renner (1975); and 3) 'social interaction' model developed by Wollman and Chen (1982). A lot of implications can be derived from these models to construct an instructional model under any given educational setting. The development of an instructional model to suit the Indian urban classroom setting is discussed in the forthcoming chapter. In this context it would be worthwhile to note the conditions given by Kimball (1973) in developing an instructional model to accelerate logical operations. He says "an individual who is to be introduced to formal operations must be facile with concrete operations: able and experienced in manipulating materials; capable of formulating generalisations; conserves number as well as area, shape, substance and volume; classifies according to multi-attributes; identifies variables; identifies relationships and manipulates them in novel ways; exhibits reversibility. An environment that encourages formal thought must now be provided: 1) A facilitator who himself is formally

operational. He is a learner as well as a teacher. He allows many divergent responses, keeping those which meet the criteria set up. He accepts each person even though that person's findings may not 'fit' or 'work' in this situation;

- 2) Surroundings are rich in material and ideas that encourage manipulation (first hand), interaction and interchange;
- 3) The learning atmosphere allows for risk taking and creativity;
- 4) Constructive intervention takes place between learner and environment and amongst learners in a sensitive manner;
- 5) criteria for acceptable results are set up by all learners in the situation;
- 6) 'Messing around' is encouraged so that learners can 'feel' the problem as well as 'think' it;
- 7) Learner is actively involved in coming to conclusions and testing conclusions in new situations. His activity is reinforced 'neutrally' by the teacher;
- 8) The type of materials present are chosen because they encourage and suggest formal thought, not stand in the way of it. Learning is tailored for the individual;
- 9) Evaluation tools are available to measure formal thought so that feedback is immediate and personal as well as shared;
- 10) The learner is placed in a situation of mild conflict and controversy with the materials and the ideas of his colleagues;
- 11) The training is from simple to complex: from concrete to abstract;
- 12) Environment allows for curiosity to be met with open discussion, mutual criticism, or support. Final arbitration is by replication with materials" (pp.231-232).

2.8 Studies Conducted in India with a Piagetian Theoretical Framework

Though in the international scene, there are umpteen studies conducted on a Piagetian theoretical framework, this trend does not seem to have caught up in India. A survey of studies conducted in this country reveals that there are only very few studies reported with a Piagetian framework. Among these studies intervention studies are still fewer. For the sake of clarity of presentation these studies have been classified into three groups viz., 1) psychometric, 2) correlational, and 3) intervention.

2.8.1 Psychometric studies

Vaidya (1974), studied certain aspects of thinking among science students of adolescent age. He factor analysed the process of thought of hundred boys and hundred girls of the age group ten to fifteen years from grades VI to X. He reports that more than 70% of X graders could not test hypotheses and generally the adolescent pupils failed to take the logical way of attacking problems. He attributes this to the status of science education. Vaidya (1979) and Sandhu (1981), attempted to factor analyse the adolescent thought. Vaidya reported loadings on ten different factors whereas Sandhu reports a unifactor structure to the adolescent thinking.

2.8.2 correlational studies

A few studies report various relationships of cognitive abilities and other variables associated in the theoretical framework. Syamala (1961), studied the development of concepts like dreams, God, etc., in a Piagetian framework. She reports that environmental factors influence the development of these concepts. Misra (1968), studied the significance of cultural background in the learning process. Mathur and Jain (1969), studied the development of 'conservation' in rural and urban school children and report differences in the development of this ability in these two groups. Rath (1972), also studied the cultural influences on cognitive growth and learning of primary school children in Orissa. He reports that cultural influences affect the cognitive development as well as learning of primary children. Chatterjee (1973) studied the development of the concept of time from early to late childhood to locate a transitional age and report that the development is gradual and a transition occurs at the age of seven to eight years and the true concept develops at the age of ten. Nalinidevi (1976), studied the development of the concept of number in school going and non school going young children and found that there is no difference in the development of the concept in the two groups. Pandey (1979), studied the classificatory ability

among six to ten year olds and reports that the ability is independent of sex; socio-economic status does not have any effect on the classificatory ability. Grade and age has effect on the classificatory ability i.e., the higher the age and grade the better they performed. Sandeep (1979) studied the relationship between classroom interaction and cognitive development. He reports that classroom interaction adversely affects the attainment of perceptual and cognitive skills. Reddy (1980) studied certain factors related to the development of concept generalisation among adults. Chand (1980) studied the development of the concept of movement among children of a wide age range (4+ to 15+ years) and found that around the age of five to seven years there was a change in the concept of movement; and formal reasoning did not develop even at the age of sixteen years. Amin (1982) studied the relationship between spatial egocentrism and conservation abilities in school children and reports that conservation abilities are related to the spatial egocentrism of school children. Banerji and Jain (1982), studied the development of conservation of number, mass and volume in rural and urban school children between the age range five to twelve years. They report differences in the conservation of number and mass between rural and urban children and no difference in the conservation of volume. Dash and Dash (1983), investigated the development of conceptual levels of representation described by Piaget

and Bruner. Each concept level had five similes varying from the most concrete to the most abstract. Young children preferred concrete similes and older ones abstract. Such a shift is attributed to change from concrete to formal reasoning.

2.8.3 Intervention studies

Kamalakanthan (1968), studied the effect of problem solving on physics concept attainment of students and reports that problem solving helped achieve the objectives of teaching science. Rao (1975), designed an experiment to study the effect of transfer of conservation of length, mass, weight and number on conservation of volume. The verbal training is reported to be more productive than the nonverbal training. Bevli (1978), tried to accelerate the acquisition of the concept of speed in children of ages 6+ to 9+ and found that the training was effective. However, it was less effective with socially disadvantaged children. Ajwani (1979), tried to develop the problem solving ability using three strategies: a) by giving specific direction b) by helping to find the method of solution and c) through learning puzzles. He reports that all the experimental groups bettered in problem solving ability. The decreasing effectiveness of the three strategies were in the order b,c,a. Jha (1979), compared an activity based approach in teaching school science and found strong

evidences in favour of such an approach in achieving application of knowledge and in the development of scientific skills. Rath and Patnaik (1979), studied the effect of training on the conservation of volume and length and report that training could bring about improvement in the conservation ability of primary children. Bala (1980), compared the effect of 'modern' and traditional mathematics curricula on concrete and formal logical thinking of children and found that modern mathematics facilitated thinking ability of concrete thinkers (grade IV) whereas it made no difference to the formal thinkers. Padmini (1980), through an intervention programme tried to develop the concept of length, area, volume, weight, the sense of belonging and spatial relationships among primary school children. She used a long term (6 months) intervention programme and found that the experiment was successful in fostering cognitive development. Mohanty and Chaudhary (1981), studied the effect of two training techniques viz., 'screening' and 'self transformation' in inducing conservation abilities in children. The transitional children were given training and found that both the techniques had significant effects. Bhattacharya (1982), used audio-visual methods to teach fractions and decimals to primary children and found that he could accelerate the acquisition of these concepts. Yadav (1982), compared a guided discovery approach to lecture in attaining higher level objectives and reports that guided

discovery is better in attaining concepts. Bhat (1982), used a comprehensive strategy for accelerating area conservation in transitional children of III and IV graders. The strategy consisted of equality and reversibility training, addition/subtraction training (the meaning of which is not purely mathematical), and training through cognitive conflict. These three procedures were used on each day (forty minutes of instruction) in the order given above and, lasted for a total of three days for an experimental group. He reports that both the III and IV graders showed significant improvement in area conservation with the treatment.

The review of acceleration studies conducted in India shows the lack of a common paradigm. The attempts seem to be rather sporadic. Though the classroom was used for acceleration in these studies there is no attempt at reorganising the prescribed curricular experiences. In short, the above studies seem to reflect an educational psychologist's perspective and not that of an educationist's - that is, to focus on the present day constraints in the actual classrooms and frame a suitable model of instruction to suit the needs of the classrooms and also to reorganise the curriculum frame based on a sound theory of instruction. It is in this background that an acceleration study is planned for the present investigation and is discussed in detail in the subsequent chapters.

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