CHAPTER II
# CHAPTER II

THEORITICAL FRAME WORK OF THE STUDY

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2.1 INTRODUCTION:

The present chapter embodies a brief discussion on the theoretical framework of the study. The theoretical background is very essential in any research endeavour. It not only helps the researcher to proceed in a systematic way but also provides scope for verification of existing facts and knowledge.

There has been a renewed interest in the intellectual development of children over the last several years. Jean Piaget is known as the major exponent of the intellectual development. His work is primarily concerned with the describing and explaining, in a very systematic way, the growth and development of intellectual structure and knowledge. The development of knowledge is an evolutionary process that take place within every individual. He believes that all individual has universal characteristics in their cognitive development. Biological maturation, experience along with an emphasise on-process and product in the attainment of intellectual functioning have resulted in a most unique system of defining cognitive structures.

Piaget's theory of intellectual development has been briefly discussed in this present chapter.
2.2. PIAGET'S THEORY OF INTELLECTUAL DEVELOPMENT

Piaget's theory, a developmental one, has its central interest in investigating how cognition evolves from infancy to later stages in adolescence. The theory of Piaget refers to as 'genetic' because it is concerned with development of the individual (Ontogenesis). Piagetian psychology is known as "genetic psychology" referring to the individual development which is different from child psychology. Piaget himself viewed that genetic psychology is not to be confused with child psychology as child psychology deals with the child for his own sake and does not consider his eventual development into an adult, but "genetic psychology" refers to the study of developmental processes that underlie the mental functions studied in general ... psychology (intelligence) interest in psychological investigation of the child ... explains the man as well as and often better than the man explains the child. (Piaget and Inhelder, 1969, (viii - ix).

Piaget's theory is a biological - experiential and interactionist model, in which cognitive development is a mode of adaptation to the world. Cognitive growth occurs from the organism's biological nature, starting with the infant's reflexes and proceeding by invariant stages to the eventual capability of abstract, logical reasoning. To Piaget, "cognition or intelligence is one kind of biological achievement which allows the individual to interact effectively with the environment at a psychological level" (Ginsburg and Opper - 1969 p-14).

Cognitive development, according to Piaget, is a continuous and sequential process from birth through later adolescence. This sequence is invariant through the age of acquisition and the rate of development
varies from culture to culture. Though there are lots of controversies regarding the concept of "invariant sequences" but it may be interpreted in the following three ways -

**First** (major developmental periods or "global stages")

(a) Sensori-motor stages from birth to about two years. In this period a child solves problem by using his sensori system and motoric activity rather than the symbolic process.

(b) Pre-operational stages (2+ to about 7 years) where children develop some specific features like language imitation, symbolic play, drawing, can frame mental image and pictures.

(c) Concrete operational period (7 to 11 years) when child can do in their head what they previously accomplished through their action. A child can think using mental operations (conservation, seriation, classification, number reversibility etc.).

(d) Formal operational, (11 years onward) where the adolescent's thought become flexible and effective. They can deal effectively with complex reasoning problems.

**Second**, there is fairly reasonable 'within-stage development' sequence of various operations for example, the conservation of mass/matter is acquired before the conservation of volumes.

**Third**, there is 'within operational developmental sequence, that is before any particular operation is acquired. There is three level of auto-regulatory process of equilibration. In the pre-operational period conservation is not acquired. During the transitional period there is
uncertainty, oscillation and unstable equilibrium. But during the final period when the operation is fully acquired the cognitive structure becomes stable and equilibrium is achieved.

Cognitive growth proceeds via two fundamental processes viz assimilation and accommodation. According to Piaget, assimilation means "taking in" the information from the outside world. Human organism can assimilate that class of information which the cognitive system is capable of dealing with at that point of time. When assimilation of information alters the individual's understanding of events this alternation is referred to as accommodation. The individual assimilates knowledge and virtually at the same time makes accommodation to this new knowledge. The knowledge that is learned from this process is organize into what Piaget calls a schema (pl. schemata), a coherent, organised set of "information" about objects, events, or whatever may be the content in question.

The role of actions with objects is central to the Piagetian explanation of how we come to know the world about us. To him, to know and construct knowledge of the world, the child must act on objects and it is this action which provides knowledge of those objects. Action of the individual on the object is not a one way activity, but is an interaction between child and object which yield new insights into a personal effect upon the environment and the environment's responsiveness to activities which have been initiated. Knowing comes not from the object alone nor from the child's action alone, but from construction of the interactions between the child and the object. The child increasingly becomes able to objectify his or her knowledge. Thus knowledge is built from actions, experiences and the interactions with the world. According to Piaget constructivism refers to that process of constructing, in effect creating a
concept which serves as a guideline against which objects or people can be gauged. During the course of interacting with objects, people or events, the individual constructs a reality of them. The object is defined mentally. This mental construction then guides subsequent action with that object or event.

Piaget asserted that development of knowledge follows a sequential order which means movement from stage to stage resulting in changes both in what one can understand and how one understands. This development also occurs in an orderly process in a bio-social context. There are basically four factors account for the sequence of development viz. maturation (biological) experience of the physical environment, the action of the social environment and equilibration or self regulation by the organism. Maturation refers to the growth of the biological structure in the individual. The evolving biological organism with increased specialisations of functions of the brain also has increased capacities for learning. As children mature, they are able to be sociable thereby extending environmental contacts. These capacities are part of the individual's biological inheritance and their realisation is very much influenced by experience in a particular culture which is also important factors for intelligence to develop. To Piaget experience encompasses sensory and motor exercise, experiences with the physical world and experience with reasoning. Exercise involves action and reaction of both the individuals and objects, and thereby leads to knowledge through direct experiences. The infant in grasping an object, releasing it and watching it fall acquires new information while at the same time consolidates the capability to repeal the action, resulting in competence. In addition to physical experience, there is another factor that promotes reasoning about the validity of
experiences. This type of experience plays an important part at all levels of cognitive development when fully logical deduction is still not possible.

A child not only manipulates objects as in the case of sensorimotor experience, nor simply abstracting singular attributes about experienced objects but also can deducing interaction relationship because he can repeat actions on objects. Piaget asserted that two kinds of knowledge come from interaction with objects, knowledge of the objects, i.e. it includes the information contained in the object itself and knowledge gained through constructive activities with objects. Knowledge gained through constructive activities with objects involves both discovery and invention. To Piaget, each time one teaches a child something he could have discovered for himself, the child is kept from inventing it and consequently from understanding it completely.

Piaget also asserted that the experimental features of the environment exert tremendous impact upon the developing organism. In cross-cultural research cited by Piaget, it has been observed that the children from low cultural background are found to be lagging behind by one or two years in mental development, while demonstrating the same sequence of stages as well as the rural children, and the rural children usually fall behind their city peers in attaining these stages. Thus knowledge of objects does not occur in a vacuum but rather in a social milieu. The stages enumerated are accelerated or retarded for the average chronological ages according to the cultural and educational environment. But the fact that the stages follow in any environment is enough to show that the social environment cannot account for everything. This constant order of succession can not be ascribed to the environment (Piaget - 1970 b, p-721).
Transition from stage to stage is an another integral concern in the Piagetian system. To Piaget, logical necessity and cognitive conflict explanations are appropriate ways to explain transitions between stages. There are certain environmental demands and events require actions that have an inherent or built-in logic. And out of this logical necessity a child responds appropriately. As for example, a child generally heard "put on your shoes and socks", rather than "socks and shoes". Thus in this circumstances the child usually heard an order which is the reverse of logic and out of logical necessity the child generally responds appropriately. There are some other situations which are built out of reality. As for example, one cannot close one's mouth and eat." There is a built-in logic to these situations and this inherent logic of events helps the child learn certain kinds of logical sequences out of necessity. These situations of logical necessity often create a 'cognitive conflict'. As for example two objects cannot be in the same space at the time unless one on top of the other and then it is not in the exact space, it is in an approximate space and time. By this way a child begins to learn the principle of displacement. As for example, two people can not sit on the same chair if it is an ordinary chair. This is observed in children's play over territory where children are struggling with this concept of displacement upon two children want to be at the same spot. The conflicts that the children have in their own activities as well as in interactions with other people, create a disequilibrium, a tension, and it is the solutions of these problems that help propel the child from one competence level to another. According to Piaget these are essentially social experiences and Piaget contend that more than social experiences accounts for transition. To him, there is another factor accounting for the transition from sensori-motor to empirical thinking, this is the advent of language. Language becomes the intermediary providing
the means by which later concepts and conceptual thinking are furthered. Thus transition between stages can be attributed to social demands and in the early years to the advent of language (Piaget, 1951).

Piaget's theory can be called developmental constructivism. Its basic postulate is that, "no human knowledge, with the obvious exception of the very elementary hereditary forms is performed in the structures of either the subjects or the object" (Inhelder, Sinclair and Bovet, 1974, p-8). Piaget contends that the "knower" or learner is constantly active in elaborating knowledge and changing perspective. The individual builds literally, a knowledge base through acting with objects. The knowledge acquired and the processes by which the constructions are achieved form an organization.

Cognitive structures are used to adapt to the environment. The particular structures are not inherited but depend on the individual's history.

In Piaget's theoretical system, actions are eventually internalised by the performer into operations. The operation is the unit of logical thinking. Operation specifies what particular mental activity is involved. The significance of this concept resides in the identification of mental activities involved in logical reasoning. Operations form the crux of thought for Piaget because they are expressions of certain forms of "Coordination which are general to all actions." (Inhelder and Piaget 1964, p-29).

Piagetian holistic theory however has been criticised because two important critical functions viz language, an uniquely human characteristic and affect (emotions and feelings) have not been discussed. Piaget has been criticised for ignoring, or at least under emphasizing, the role of affect (emotions and feelings) in the development of intellect. Such
assertions are far from the birth. For Piaget, affect and cognition are interwoven and hence indissociable, even though distinct systems (Piaget, 1973). The affective system is the energizer, and by its positive and negative connections, it may cause the acceleration or the delay of cognitive development. To quote Piaget, "this does not mean that affectivity produces or even modifies the cognitive structure (reasoning or thinking system) whose necessity remains intrinsic .... it goes without saying that if the affective stems from an energetic then the cognitive stems from structures" (Piaget 1973, p-47). Thus there are two systems, the affective (the energizer, the mover), and the cognitive (the organised system of thinking and reasoning). Piaget’s research efforts tend to emphasize the cognitive system through which the child construct knowledge.

The above concept form the overall set of factors essential to the development of the stages of intelligence.

2.3 BIOLOGICAL THEORY OF KNOWLEDGE

Jean Piaget found a close connection between biology and the development of knowledge. He saw the continuity between the biological intelligence as shown even by plants and lower animals and human knowledge as it develops from infancy onwards. Piaget noticed that just as snail’s reconstructed their shapes as a way of surviving in a hostile environment similarly child also reconstruct his action and ideas in relation to new environment experiences - e.g. to adapt the table manners of adult. During this on going relationship with the environment, the child exhibits at certain ages characteristic structures on organisations of action and thought which Piaget has classified as stages. Piaget’s greatest contribution is his brilliant analysis of how human knowledge slowly
develops beyond its biological inherited origins through a process of self regulation based on feedback from environment leading to internal reconstruction. The ability to adapt to new situations through self regulation is the common link between all living things and the basis of Piaget's biological theory of knowledge.

Psychology emphasised on learning and explain behaviour in the language of stimuli and responses. But Piaget's system does not have these characteristics. Instead it has a distinctly biological flavour. This flavour is usually attributed to the fact that Piaget is a biologist by training. Piaget has borrowed some well known descriptive principles of biological growth (organisation and adaptation) and has used them to describe the development of human intelligence. Piaget believes that biological principles are directly applicable to the study of intellectual growth. Specially he maintains that (a) the growth of intelligence is a special case of growth in general. (b) we must understand biological development if we are to understand intelligence and (c) the study of intellectual development is rightfully a branch of embryology (Piaget -1967b, 1970 b).

Piaget's description about the development of knowledge is totally different from that Lamarck's discredited theory of the inheritance of acquired characteristics. Piaget feels that living organisms are active and self regulating in their choices of ways to adapt. Here Piaget also differs from Darwin, who sees organism is essentially passive, dependent on chance mutation and natural selection for survival. For Piaget, adoption is on the contrary a dynamic, on going process in which the hereditary structure of the organism inter-acts with the external environment in such a way as to reconstitute itself for better survival. Piaget also believes that the intellectual adaptations that occur during the course of development
are always meaningful and are never the result of trial and error.

The third sign of Piaget's biological orientation is the strong emphasis he places on the role of children in determining the course of their own cognitive development. Piaget viewed that children exert as much control over their development as do factors located in the children's environment (parents, schools, churches etc.) Piaget's organism centered approach, stands in sharp contrast to the learning interpretations of intellectual development that have been popular in North America i.e. children are not assigned a crucial role in determining their own cognitive development. Instead intellectual development is seen as a process by virtue of which factors located in the environment make impression on the "wax-tablet" of the child's mind. Cognitive development becomes synonymous with cumulative experience. In contrast Piaget believes that children are capable of alternating the forces as well as being altered by them. Hence both children and their environment are necessary parts of Piaget's formulation where as only the environment is essential in the traditional learning approach.

Fourthly, Piaget has been concerned almost exclusively with cognitive development. Like modern entheologist - he has placed strong emphasis on "natural" development.

A fifth example of Piaget's biological orientation is his belief that the direction that intellectual growth takes is always from simple to more complex levels of functioning.

Piaget's system of development of knowledge is known as genetic epistemology. 'Genetics' here refers to the developmental point of view. Epistemology is the science, that studies the origin of knowledge,
growth and nature of knowledge. Therefore genetic epistemology is the study of how the individual acquires knowledge. Piaget himself used this term "genetic psychology" in his (1969) discussion regarding his system.

2.4 PROCESS INVOLVED IN COGNITIVE DEVELOPMENT OR STAGES IN COGNITIVE DEVELOPMENT.

Piaget's theory is a stage invariant theory rather than age invariant which means that the order of the stage does not vary. Every one has to pass through these stages in the sequence. Nobody can skip any stage nor reverse the progress. Thus Piaget has divided the developmental sequence into stages and period. The range of these is stated using chronological age. But from the Piaget's writings it is clear that the ages he gives for certain levels of thinking can be regarded only as guidelines or rough averages for children development. One can expect to find that their is considerable deviation from these norms. Some children do not reach the end of the developmental sequence. Some reach a given stage earlier or later than others. At any given stages in the sequence, modes of thinking characteristics of the earlier stages are present and on occasions children may revert to modes of thinking which are more characteristic of earlier years. Piaget (1967) asserts that there are four basic stages of cognitive development. These are:

a) The development of Sensori-Motor Thinking - from birth to about 2 years.

b) The emergence and development of symbolic thought : Pre-Conceptual Representation: (2 to 7 years)

c) The progress of Concrete Operations : the threshold of formal operations: (from about 7 to 11 years)
d) The emergence and development of Formal Operations (from 11 years onwards).

a) Sensori-Motor Period (Birth to 2 years) - The first two years of life have been described by Piaget (1945) as the Sensori-Motor period, because in this period a child solves problem by using his sensori system and motoric activity rather than the symbolic processes. The child's knowledge about object comes from his actions on them. At birth the infant has no knowledge of the existence of the world or of himself. His innate behaviour patterns are exercised in the environment and modified by the nature of the things he acts upon. His sensori-motor systems become co-ordinated during this activity. Gradually the baby builds up internal action models of the objects around him by virtue of the actions he has performed with them. He recognises objects by means of these. This internal model of his actions allows him to perform mental experiments upon the objects he is manipulating physically. The result of performing actions with this internal model is sensori-motor thinking i.e. internalized action.

Piaget, extensively studied about the development during the sensori-motor period (1954). Accordingly to him in this period the child accomplishes the following tasks; attaining rudimentary knowledge of objects, people and events which become the basis for later concepts, differentiating the self from objects localizing the self in physical space; establishing the beginning awareness of cause and effect and of time and space - in part this happens because the child has acquired the ability to identify the permanence and substantiality of objects during this period.

In the course of this development the child goes through six stages. In the first stage which lasts about a month, the child shows little
besides reflexive behaviour. In the second stage, from about one to four months, various reflex activities become modified with experience and co-ordinated with one another. In stage three between four and eight months, infants begin to act towards object and events outside their own bodies as though they have some permanence and stability. During the fourth stage between eight and twelve months, intentionality of purpose is observed in children. The child tends to use what has already been learned in searching for objects as well as repealing patterns of behaviour. Children between twelve and eighteen months of age reach stage five, begin to experiment to search for new ways to solve problems and to become excited about novelty for its own sake. Finally at stages six, between eighteen months to approximately two years, children show the capacity for primitive symbolic representation. They may invent solutions mentally, that is symbolically rather than by trial and error. With the beginning of the symbolic thought, they approach the next phase of development.
Table 1

OUTSTANDING CHARACTERISTICS OF SENSORI-MOTOR STAGE

<table>
<thead>
<tr>
<th>Stages</th>
<th>Action</th>
<th>Age</th>
<th>Characteristics</th>
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<tbody>
<tr>
<td>1.</td>
<td>Reflex Action</td>
<td>First</td>
<td>The child exercises the native reflexes. E.g. the sucking reflex. The mental development originates during very first month. (Reflex become efficient and more voluntary movement replace them)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>month</td>
<td></td>
</tr>
</tbody>
</table>
| 2.     | Primary circular Reaction.  
(Primary means first, circular reaction means repeating the act) | 1-4      | Infants repeat some acts involving the body. E.g. finger sucking (Repetition of interesting body movements.)                                        |
|        |                                     | months   |                                                                                                                                                  |
| 3.     | Secondary Circular Re-actions       | 4-8      | Children repeat acts involving objects outside themselves. E.g. Infants continue to shake or kick the legs.                                        |
|        |                                     | months   |                                                                                                                                                  |
|        |                                     | months   |                                                                                                                                                  |
| 5.     | Tertiary circular Reaction          | 12-18    | Children repeat acts not only for repetition sake. They search for novelty E.g. Children of this stage continually drops things. Piaget interpret such behaviour as expressing their uncertainty about what will happen to the object when they realise it. |
|        |                                     | months   |                                                                                                                                                  |
| 6.     | Mental representation of actions.   | 18-24    | Primitive type of representation appears. (Thinking prior to action)                                                                               |
|        |                                     | months   |                                                                                                                                                  |

Sources: The Cognitive Theory - Piaget and Bruner. P-129.
THE EMERGENCE AND DEVELOPMENT OF SYMBOLIC THOUGHT: Pre-Conceptual Representation (Two to Seven Years):

As child reaches two years he moves from a prone, non-verbal organism to an upright, verbal, and mobile child. In the sensori-motor period, the child's wants and needs had been communicated, indirectly, but in this period language is employed. Emotionally the child can define a self and person separate from others. However, this period is characterised by two sub-phases, pre-operational and intuitive.

Pre-Operational Phase (Two to Four years):

In this phase instead of thinking and reasoning through action, i.e. experimenting and operating externally and concretely. The child is approaching the ability to function symbolically. He is able to distinguish between the signifier - that which stands for something - and the actual object. With the beginning of symbolic thought, language plays an increasing role. This distinction is very clearly presented by Flovell. First, the sensori-motor intelligence is capable of only linking one by one; the successive actions of perceptual stages with which it gets involved. Piaget linkens it to a slow motion film which represents one static frame after another, but can give no simultaneous and all-encompassing purview of all the frames. Representational thought, on the other hand, through symbolic capacity has the potential for simultaneously grasping, in a single internal epitome, a whole sweep of separate events. It is a much faster and more mobile device which can recall the past, represent and anticipate the future in one temporarily brief organized act. (1963, pp. 151-152).
Intuitive Phase (Four to Seven Years old)

The next phase of intuitive thought is still somewhat part of the same epoch but with a transition to increased symbolic functioning (Flavell, 1963, Piaget and Inhelder, 1969). In this stage too, child is still ego-centric, dominated by perception and subjective judgement. In this period, child develops three fundamental operations viz. the ability to think in terms of classes, to see relationship and to deal with number concepts. A child is now said to be intuitive because they do not necessarily verbalize or indicate awareness of classification but can also utilise numbers and to order things in terms of quality. They become able to disregard certain properties of items and see that a relationship can exist on a numerical basis even though the objects differ structurally. They can count different objects, thereby producing a sum, which is an abstraction.

TABLE 2.1

INTERPRETATION OF THE PRE-OPERATIONAL PERIOD

<table>
<thead>
<tr>
<th>Age</th>
<th>Language Development</th>
<th>Motor Development</th>
<th>Piaget's Cognitive Development</th>
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<tbody>
<tr>
<td>2-4 years</td>
<td>Uses sentences, answers, questions, vocabulary may approximately 1500 words.</td>
<td>Runs, jumps, throws ball, overhead rides tricycle puts on shoes.</td>
<td>Increasing use of symbolic language, play drawing.</td>
</tr>
<tr>
<td>4-5 1/2 Yrs.</td>
<td>Begin to use five or six word sentences.</td>
<td>Hops, skips, throws ball well, laces shoes.</td>
<td>Use of symbolism grows, but is still restricted.</td>
</tr>
<tr>
<td>5 1/2 - 7 Yrs</td>
<td>Uses complex sentences, vocabulary about 3000 words.</td>
<td>Jumps from height, draws recognizable man, dresses and undresses.</td>
<td>Approach logical thinking.</td>
</tr>
</tbody>
</table>

Source: The Learner and Development. p-133
During the period from approximately seven to eleven years of age, reasoning processes begin to appear logical. As the child reaches this stage, the traditional age of reason he begins to experiment with objects with images or symbols and finally with thought. The child is able to think in terms of classes, relations and number. To be able to do that, he has to be able to understand reversibility and conservation.

Piaget describes logical operations such as the ability to return to the original point in thought (reversibility), organise objects into hierarchies of classes (classification), or arrange items along continuous of increasing values (Seriation). The consequence of the child's acquisition of these concrete operations is an increasing ability to deal with concepts. The transition from the pre-operational to the operational stage is exactly a move toward the competence to think and reason in operational terms. The child becomes capable of classifying, ordering and relating classes of objects mentally rather than having to act out these processes as in the sensori motor period. One of the major achievements that becomes possible at this period is the child's ability to conserve, Conservation refers to the child's ability to understand that an attribute (number, quantity space) remains constant in spite of changes in its appearance.

Every conservation proceeds in three development stages. Stage I, no conservation present, Stage II, transitional, where there is no logical awareness and justification but inconsistently employed, Stage III, conservation, with a statement of logical justification.
Besides conservation, a child also develops the concepts of reversibility, classification, seriation, transitivity, combinatorial thinking and so on.

**Reversibility:**

Reversibility refers to the ability of the individual to re-arrange thoughts mentally to return to the starting point. For Piaget, reversibility is a 'vital mechanism' for integration of cognitive structures in every stage (Inhelder and Piaget, 1958). To solve the number conservation problem, the child must realise that if the change in row were returned to its original arrangement, it would be equal in number to the original array. Reversibility also incorporates two other operations: reciprocity and negation. Reciprocity involves compensation. For e.g. if a piece of clay in the form of a sausage is rolled into a ball the diameter increases as the length decreases, with no change in amount. The effect of the increase in diameter is compensated by a reduction in length. Negation, refers to the cancelling operations there is another operation which cancels it, as substraction negates addition. Negation and reciprocity are two types of reversibility that are involved in operational thought.

**Classification:**

Classification is the second operation involving organising items into categories. Pre-operational children can classify objects on the basis of perceptual attributes such as colour or form. Grouping items by a single attribute, whether colour, form or use indicates the child is overlooking other characteristics. During the period of concrete operations children are beginning to demonstrate an ability to classify objects on the basis of more than one attribute simultaneously such as colour and form.
Class inclusion is the ability of a child to classify objects in a hierarchical order by creating more extensive classes. A child also becomes able to realise that a sub-ordinate class, such as animal contains sub-classes such as horses.

**Decentering or decentration:**

Decentering or decentration refers to the ability to shift the focus from one attribute to another while centering or centration refers to the fixed, rigid and inflexible approach to the object. For example, tumblers are for drinking and hammers for banging, tumblers are not vases nor are hammers useful in other ways. The move toward decentration enables the individual to engage in concrete operations. The pre-operational child centers on one attribute and is not able to shift perspective. However, the concrete operational child decenterers, altering perspective by combing two classes and simultaneously separating them based on other criteria. This process indicates the mental flexibility necessary to solve the class inclusion problem.

**Seriation:**

Seriation, is the other operation which develop in this period. Seriation consists of ordering elements according to an increasing or decreasing dimension. The children have to establish relations according to a descending or ascending order. Initially, children do not order things into a single series. If young children are given a series of different sized sticks they may order the smallest and the longest, but will have difficulty in ordering the intermediary sticks. But after children have acquired seriation, they can solve problems involving one to one serial correspondence. This is a key prerequisite for understanding numbers and
carrying out arithmetic functions (addition, subtraction, multiplication and division).

**Transitivity:**

Transitivity when the child finally achieves this operation, a mode of deductive composition previously unknown is achieved which is called as transitivity. Transitive literally means passing over to an object. E.g., \( A < B; B < C \) therefore \( A < C \). Transitivity is an important logical reasoning operation which also involves identification of particular relevant attributes of a probe. A common example is the relation. Mita is taller then her sister Rita. Rita is taller then her cousin Sarita. Then Mita is taller than Sarita. The question is who is the tallest. The solution to the problem is dependent on the child deciding that the critical variable is height and not kinship. The child has to separate the variables and attend to the significant ones. Pre-operational solutions to this problem are unlikely since at that period children have difficulty identifying the relevant variables. The child at the concrete operational period has acquired the ability to discriminate the relevant variable.

**COMBINATORIAL THINKING:**

In concrete operational period a child show the beginning of combinatorial thought, a fundamental formal operation which builds upon the classification system. The child can work with two independent attributes at the same time. They can classify object on the basis of seriation as well as can solve combinatorial problems that do not involve seriation. Combining two or more attributes is another cognitive function which a child can perform in that period. But they are not able to create combinations if qualities of objects are not apparent. Number, as a concept
is more that simple counting which is developed in concrete operational period. Comprehension of number as a concept is more that simple counting. Conservation of number means that a child can understand the principle of numerical equivalence. For Piaget, number is a synthesis of seriation and class inclusions.

**Quantity:**

Quantity - Related to the number concept, is the concept of quantity or amount. Concept of quantity relates to the mass that is involved. Many conservation studies with children during the operational period have to do with the conservation of quantity. For example, the child is asked whether the same amount of clay exists when changed in shape from a pancake to a sausage. The child learns that the amount does not change in spite of the transformation in forms. In this period the child become aware that the amount does not changes in the face of physical transformation, just as the number does not change when different object are enumerated.

The conservation studies have shown that conservation of mass (substance), precedes the conservation of weight and volume. The order is invariant.

**(d) Formal Operations :**

The formal operational period begins at 11 or 12 years for most youngsters and is the culmination the previous three periods. Ginsburg and Opper (1969) describes formal operations as the time when the adolescent's thought becomes flexible and effective. Adolescent can deal effectively with complex reasoning problems and can also imagine many possibilities in a problem. They are not bound by the tangible or concrete,
which is the major achievement of this period. Piaget and Inhelder (1969) state that decentering is complete and that the adolescent can understand and use hypothetical statements while reasoning about propositions that are not concrete. They also note that adolescent's thinking are so advanced that they can reason correctly about propositions they do not believe and can draw conclusions from statement that reflect only possibilities. The formal operational individual segregates the variable, eliminates contradictions, and combines variables in a logical way. The child is capable of creating logical combination, and verifying hypotheses.

Piaget's theory is a stage dependent one in which the child is said to move in an invariant order through major periods and stages each specifying the necessary operations required passes through different period results in transformations, substitutions and integrations. Though Piaget has tied these periods with certain ages, but he has indicated that they are only guidelines and not to be treated as fixed. The chronological ages can be used only as estimates of when certain kinds of function may be expected. Infact, children at various ages employ behaviours which are characteristics functions of many of the periods.

2.5 THE DIFFERENCE BETWEEN PRE-OPERATIONAL, CONCRETE, OPERATIONAL AND FORMAL OPERATIONAL THOUGHT:

The thought of pre-operational child is characterized by dominance of perception over reasoning, ego-centricism, centration, inability to follow transformation and inability to reverse operations. In contrast the thought of concrete operational child is free from all the characteristics that dominated perceptual thought. His thought is less ego-centric. He can solve the conservation problems. He follows transformation
and he can reverse operation when conflicts arises between perception and reasoning. The concrete operational child make judgements based on reasoning. But the child cannot deal with complex verbal problems or those involving the future. The child with the fully developed formal operations can deal with all classes of problems; the present, past and future, the hypothetical and the verbal.

Thus, the child with formal operational is liberated from concrete problems. The concrete operational child cannot integrate his solution of problems by means of general theories. Formal operation are characterized by scientific reasoning and hypotheses building.

2.6. CONSERVATION - A CRITIQUE:

Conservation is a very important scheme of thought in the Piagetian literature. It plays a central role which is a necessary condition for all rational activities. The acquisition of various types of conservation is one of the most important components of the transition from pre-operational to the concrete operational stage. Conservation refers to the cognition that certain properties (e.g. mass/weight/volume) remain invariant in face of certain transformations such as displacing the object part in space, sectioning the object into pieces or changing the shape etc. Piaget asserts that evolution of conservation is a process of equilibration of cognitive action which consists of three major steps i.e. complete conservation, partial conservation and non-conservation. In other word conservation could be defined as an operational process of the mind which produce the realization that certain aspects of a changing conditions are invariant, despite those change. It can be seen that conservation and reversibility are closely related and Piaget express this fact as follows:
"Conservation has thus to be conceived as the resultant of operational reversibility."

Conservation has been a major concern of most Piagetian studies. He performed a number of experiments to determine how and at what age or stage of mental development children began to realize that when the appearance of an object is changed, it does not mean that all the properties of this object have also changed. The properties with which Piaget (1940) first concerned himself were those of weight and volume. To test conservation, Piaget used his famous plasticine ball and sausage experiment and asked the children whether the plasticine had the same mass or substance, the same weight and same volume. Piaget found that the understanding of conservation followed a regular order that was related to age. The child's acquisition of the various conservation begins at around six to seven years (except in the case of the conservation of objects, which appeared at the end of the sensori-motor period). Substance (quantity may be conserved between six to eight years, weight at around nine or ten years and volume perhaps eleven or twelve years. However, there is a wide age range at which children acquire the various conservations. As far as the order of acquisition of the various conservations is concerned, Piaget makes the following comment, "It is more difficult to order serially to equalize, etc. objects whose properties are less to dissociate from one's own action, such as weight, than to apply the same operations to properties which can be objectified more readily, such as length." (Logical thinking p-249). It can be noted also that some conservations rest upon earlier conservations, for example velocity, and therefore will appear later rather than earlier.
Piaget's experiment on conservation has been replicated in various forms by others. Uzagiris (1964), Elkind (1961), Lovell (1960), and Ogilvie (1961) generally confirmed Piaget's theory of sequential attainment of conservation in different concepts. However, it should be noted that its sequence was not always constant when different materials were used in different cultural background.

2.7 SEQUENCE OF CONSERVATION DEVELOPMENT OF CHILDREN:

Conservation of different concepts requires some different prerequisites operation. With the development of conservation of one concept the child acquires some operations which help him in acquisition of conservation of other concepts, like multiple classification, multiple relationality, seriation etc. From the study of different researcher, the sequence among children's concept development can be tabularised as follows:
Table : 2.2
SHOWING APPROXIMATE AGE LEVELS AT WHICH CONSERVATION IS ATTAINED, IN GENERAL

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Types of Conservation</th>
<th>Age</th>
<th>Characteristic response of child</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Number</td>
<td>6 1/2 - 7</td>
<td>Realizes rearranging of objects does not change their number.</td>
</tr>
<tr>
<td>2.</td>
<td>Length</td>
<td>7 - 8</td>
<td>Realizes bending a wire does not change its length.</td>
</tr>
<tr>
<td>3.</td>
<td>Weight</td>
<td>9 - 11</td>
<td>Realizes a mashed piece of clay weighs the same as when it was a sphere.</td>
</tr>
<tr>
<td>4.</td>
<td>Area</td>
<td>8 1/2 - 11</td>
<td>Realize the area of a paper split in half covers just as much area as it were whole.</td>
</tr>
<tr>
<td>5.</td>
<td>Volume</td>
<td>12-14</td>
<td>Realize that a mashed piece of clay immersed in a liquid and above will occupy as much volume as when it was a sphere.</td>
</tr>
</tbody>
</table>

Cega Peter (page 13), science in Elementary Education. Bybee, Sund (page 102), Piaget for Educators.

2.8 CONSERVATION OF NUMBER:

Conservation of Number indicates that the number indicates that the numerical equality between two collection of objects remain unchanged following a change in the spatial arrangement of the objects provided no objects are added or taken away. During the concrete operational period children begin to conserve number, which means that they can understand the principle of numerical equivalence, that is, one apple and one car are equivalent as far as number is concerned. For Piaget, number is a synthesis of seriation and class inclusion. In the seriation problem, ordering items in terms of numbers (1, 2, 3, 4, 5, and so on) indicates that each number in the ascending order is more than the previous numbers and one less than the subsequent one. To understand this principle requires the child to deal
with the abstraction that in the world of numbers, it is the number that is equivalence and that on that basis a comparison is made. Yet the class inclusion issue is also present which help the child to distinguish a particular class from that of another class.

Number is thus essentially a fusion or synthesis of two logical entities, class and a symmetrical relation. Piaget (1952) analyses the three stages in the development of conservation of number. Gelman (1972) and Pufall and Shaw (1972) have demonstrated that children tend to use length to judge number, at least during the early stages of quantitative concept development.

2.9 CONSERVATION OF LENGTH :

Conservation of length means, change in the position, arrangement or shape will not increase or decrease its length, until and unless something is added or subtracted from the original materials. According to many logicians, measurement is possible in a dimension only when relations between objects in the dimensions fulfil certain axioms of measurement (Bergan and Spence 1944, Nagel 1930). When length is measured, it is assumed that lengths are additive, i.e. any length is composed of shorter lengths added together. Some arbitrary units (e.g. inches, centimeters) may be defined length of a measured objects is the number of units which have to be added together to compare another object equal in lengths to the first.

In most studies of length judgement in children, they have been asked to compare two lengths. The method used by children to arrive at a judgement is likely to depend both on the stimulus conditions and on the manner in which a child is obliged to communicate his judgement.
A child's ability to perform the inferences basic to measurement is based entirely on his measuring behaviour which reflects his knowledge of measuring technique, as much as it does his ability to reason logically about length. Motivation of the child is a factor for Piaget's studies of measurement. It is found that in the absence of measurement, the responses vary. It is seen that, older children are more interested than the younger children in measurements.

2.10 CONSERVATION OF WEIGHT:

Conservation of weight means, a change in shape of an object will not alter its weight. After Piaget and Inhelder (1941) a number of studies investigated whether a child appreciates that changes in the shape of an object do not cause changes in its weight. They argued that children's thinking was frequently dominated by perceptual centering, usually on a single dimension. It is more because it is longer. Elkind (1961), Beard (1963), Uzagiris (1964), Smedslund (1961) studied acquisition of conservation among children and it is believed that the acquisition of conservation is not related to practical experience alone. It also involves the children in a mental conflict between thought processes based on a visual deformation or other physical change and those based on logical thinking.

Fogelman (1970) has summarized the result on the main replication researches in the following table:
TABLE- 3

SHOWING PLASTICINE BALL AND SAUSAGE (ON EQUIVALENT) TEST, IN CONSERVATION OF WEIGHT-AGE-RANGE ABILITY

<table>
<thead>
<tr>
<th>Age</th>
<th>Percentage showing conservation according to</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beard</td>
</tr>
<tr>
<td>5</td>
<td>33.3</td>
</tr>
<tr>
<td>6</td>
<td>45.0</td>
</tr>
<tr>
<td>7</td>
<td>48.9</td>
</tr>
<tr>
<td>8</td>
<td>29.2</td>
</tr>
<tr>
<td>9</td>
<td>58.3</td>
</tr>
<tr>
<td>10</td>
<td>--</td>
</tr>
<tr>
<td>11</td>
<td>--</td>
</tr>
<tr>
<td>12</td>
<td>--</td>
</tr>
</tbody>
</table>

Source - Fogelman (1970), p - 4)

Different researchers showed considerable variation. It shows that responses given by children are affected by the different variable. The way materials are used, the wording of questions and the selection of samples, all affect the result.

2.11 CONSERVATION OF AREA :

Conservation of area means, a change in the arrangement of the parts of an object will not alter its total surface area i.e. the total surface area of the parts of an object is equal until and unless something is added or substracted from it. Conservation of area also occurs during the concrete operational period of the child approximately at the age of 8 to 11 years. From the various research study it was found that younger children generally
relied on perceptual impression but older children ignored this visual aspect and had reasons based on the use of simple logic. The responses of older children were based on reversibility of thought. As the child’s conception of area develops, he always recognizes that, when a shape is broken up and all the pieces resembled, the total area always remains the same although a single dimension may be greatly increased. If the situations are made more realistic closer to children’s everyday needs, they will not make the incredible errors in quantitative reasoning.

2.12 PIAGET’S CONSERVATION PROBLEM:

Piaget, while collecting data for sustaining his theoretical standpoint, he used clinical but not experimental as a method of investigation. Such a method of investigation has an inherent drawbacks of incorporating subjectivity into the data. Piaget has identified several conservation problem on tasks. Irrespective of the content of these problems they routinely involve presenting the subject with a variable (V) and a standard (S) stimulus that are initially equivalent in both the perceptual and the quantitative sense. The subject is then asked to make a judgement regarding their quantitative equivalence. Once the judgement is made the variable stimulus is subjected to transformation V-V', which alter the perceptual but not the quantitative equivalence between variable and standard. After completion of the transformation, the subject is asked to judge quantitative equivalence between the standard and the transformed variables. The entire problem can be symbolically represented as follows:

\[
S = V \quad V = V' \quad S \neq V
\]
To illustrate this, the problem of weight conservation (Piaget and Inhelder (1962) can be taken where the child was presented with two clay balls (V and S) equivalent in size, appearance and weight, and was asked whether they were of same weight. One of these balls (V) was then transformed into a 'pancake' or a 'Sausage' or a number of little balls. The child was then asked to judge whether V has more, less or the same weight as S.

According to Elkind, (1968), the datum of the conservation of problem, the judgement regarding the equality or inequality of S and V can be viewed as indicative of two different forms of conservation. The first form of conservation i.e. the conservation of given weight length number etc. across a reversible transformation and with respect to itself alone. If, for example, one ball of clay was employed in the weight of conservation problem then the judgement that a child makes will not be in terms of S = V', but in terms of V = V'. This is called the "conservation of identity." (Elkind 1968). In the conservation problem, the identity conservation must be inferred from the child's judgement regarding the relation between S and V and S and V'. In the second form of conservation the child makes a judgement to exhibit his knowledge of the invariance of a quantitative relation between two elements across the transformation of one of the elements of that relation. It is this form of conservation which is called the "Conservation of Equivalence" (Elkind 1968) that a standard conservation problem assesses.

In a standard conservation problem there is no inference to be made by the experimenter for assessment of equivalence conservation because the child's judgement of S and V' and S and V' are direct indications of the child's beliefs to whether a relation change across a change in the elements of that relation or not.
The conservation of identity can be viewed as a necessary condition for the conservation of equivalence. In the absence of a perceptual means, whereby the child can determine that \( V' = S \), he realizes on his previous experience or having judged \( S = V \) and of having seen \( V \) transformed into \( V' \). It is through these past experiences that the child deductively reaches to equivalence of conservation. The essential requirement to identify conservation for utilizing these past experiences leading to conservation of equivalence is shown by the following paradigm (Elkind, 1968).

<table>
<thead>
<tr>
<th>Conservation of Equivalence</th>
<th>Non-Conservation of Equivalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘S’ judges ( S = V )</td>
<td>‘S’ judges ( S = V )</td>
</tr>
<tr>
<td>‘S’ judges ( V = V' )</td>
<td>‘S’ judges ( V \neq V' )</td>
</tr>
<tr>
<td>‘S’ judges ( S = V' )</td>
<td>‘S’ judges ( S \neq V' )</td>
</tr>
</tbody>
</table>

Though the conservation of identity is a necessary condition for the conservation of equivalence, it should be mentioned that, it is not a sufficient condition for the conservation of equivalence. The child not only uses conservation of identity but also he has to utilise his past experience in the form of deductive argument. Essentially the conservation problem intends to know how a child comes to deal with an object that is varying in two inverse directions simultaneously. While explaining Piaget visualizes the use of mechanism of "equation of difference" (Piaget 1952) or "Compensation" (Piaget and Inhelder 1962) by the child. According to him a child gradually comes to realize that for any given object a change in one dimension is exactly compensated by an equal and inverse change in a second dimensions. It is this discovery that, when the dimension of a
given quantity are altered, the dimensional differences compensate one another underlies the child's insight that transformations are reversible and that they have the object (property or quantity invariant).

Elkind (1968), in his article has pointed out the Piaget's viewpoint, "The process of retro-action lead (the child) sooner or later to consider as field, not simply the successive changes in A₀, A₁, A₂ (for example the increasing length of the ball made into a sausage) nor exclusively the successive changes in B₀, B₁, B₂ (for example decreasing diameter of the sausage) but rather their relation."

\[ A₀ - A₁ - A₂ \]
\[ B₀ - B₁ - B₂ \]

Elkind in his writing has pointed out that position has not yet changed over years and that Piaget's discussion of conservation is primarily aimed at explaining the conservation of identity and not the conservation of equivalence. That is to say the equation of differences refers to the compensation of changes within one and the same object and not to the relation between standard and variables, directly assessed by the conservation problems. It is customary in any conservation problem to ask for the children's verbal explanation of conservation. According to Elkind (1968), commonly found verbal explanations are -

(a) Nothing has been added or taken away so it is the same (identity).

(b) If you made it like it was before it will be the same (reversibility).
(c) What it lost in one way it gained in another (equation of differences or compensation).

These verbal explanations may not be reflecting the actual process leading to conservation. But they reflect the attempt made by the child to give logical explanation to the conservation or non-conservation judgement. It is not the content of these explanations but the conviction on the part of the children, that conservation is logical necessity and that he must justify it which is of central importance.

2.13. GEOGRAPHICAL LOCATION OF THE PIAGETIAN STUDY:

A large number of replication studies have been conducted using Piagetian tasks across continents and countries to confirm the findings of Piaget. Cower (1978) reports the following studies to show the geographical location covered.

1. Europe and the Middle East:

Switzerland and France (Piaget and Inhelder 1966), Germany (Aabli 1970), Italy (Peluffo 1962), Norway (Hallos and Cowan 1973), Sweden (Bergling 1974), Hungary (Hallos 1975), England (Vernon 1965), Iran (Mosheni 1966), (Leberman 1974).

2. North America:

3. West Indies (Vernon, 1965).

4. Costa Rica (Youniss and Dean, 1974).


6. Hong Kong: (Soodnow and Belthon 1966)


All these studies are stated to be supporting Piaget's general statements about age progressive and sequence. Many of them shows that concrete operations seem to emerge near the age of seven even in children from cities such as Geneva from rural Tiv in West Africa and Greek born urban white children living in Australia.

There are, however some reports of different rates of development when children of two countries are compared. Some writers (e.g. Kopalbarg 1968) conclude that there may be somewhat slower development in children of non Western culture who have not gone to school).
Piaget's theory of cognitive development was evolved through decades of patience and purposeful research. Piaget undertook the study of the development of knowledge in the individual through his life span as an important method of investigating the more extensive issues of the development of our epistemological system. He argues that the three process - the adaptation of the organism to its environment during growth, the development of intelligence in the course of the construction of its own structures and the establishment of cognitive relations, involve sets of cognitive structures constructed and continuously reconstructed in interaction between the subject and the external world. One of the central assumptions of the theory is that, in order to know something one must act upon it and thereby transform it, and related to this, that structures are the result of such construction. In his own word - "The living organism is not a mirror image of the properties of its environment. It involves a structure which is constructed step by step in the course of epigenesis" .... (Piaget 1945).

Piaget makes a clear distinction between two types of knowledge - operative and figurative. The operative knowledge refers to those activities that transform reality whereas the figurative only attempts to represent reality as it appears. For Piaget's theoretical system the distinction between these two aspects of knowledge is crucial and both these aspects are involved in cognition. Operative function serves in the structuring of the figurative aspects, and knowledge is not a passive copy of external reality, but it transcends and transform the latter.
The distinction between figurative and operative aspects of knowledge is closely linked with that of empirical abstraction and reflexive abstraction the emphasis on which is found threaded through recent volumes by Piaget that elucidate further the meaning of equilibration. Whereas empirical abstraction is based on what is observed (information gathered from exogenous or external source), reflexive abstraction is based on what is related, coordinated or integrated in available information. Reflexive abstraction is actually another term for logico-mathematical knowing which is of necessity, constructive and endogenous or intrinsic (Gallagher et al 1978-80). Piaget explains “Reflexive abstraction does not replace empirical abstraction but frames it from the start and then goes infinitely beyond it.” Thus cognitive development is a dynamic process influenced by both environment and maturation. Though the process of development is explained in terms of several concepts, principles and mechanism that Piaget identified (more important to some like Rheta Devries 1978), it is described in terms of invariant sequence of qualitatively different stage with each stage necessary for launching one on to the next stages.

Piaget’s theory is relevant and suggestive to education in at least three ways -

(i) The theory provides a developmental perspective to teachers and curriculum builders since it focuses on the domain most relevant to education. Piaget has documented in great detail the stages of development from infancy to adolescence and it serves as a framework to select and develop appropriate materials, situations and tasks and to order them. The focus should be on systematization of experiences according to the cognitive level of the child, maintenance of order and co-herence in
providing developmental stimulation being one of the most important principles of instruction. The effectiveness of exposure to perceptual attributes and arrangement, incorporation of symbolic manipulation and promise of inductive generalization and abstractive construction all depend upon appropriate sequencing. In short, stimulation sequence must be suitably timed and spaced.

The second function of stimulus pacing is feedback, it furnishes teacher with a constant psycho-cognitive assessment of a child's developmental learning process (Fowler 1968). "By using an indices, a child's task mastery and motivation, a teacher has a built in method of deciding when to proceed to the next phase, when to review certain components. Moreover this assessment enables teacher to search for, observe and become aware of 'learning paralysis' at a given level (Fowler 1968)".

ii) Piaget has offered a mass of substantive data on the forms of knowledge and knowledge getting process capable with sound educational objectives. This facilitates the essential analysis of subjects in different areas into component of instruction for it is useful to analyses a concept into its constituents with a thorough knowledge of the concept and its development in the first place. Thus introduction and gradation of concepts with suitable operations in different subject areas in general and in science and mathematics in particular may be guided by Piaget's meaningful findings.

iii) The theory makes for significant extrapolation of principles and rational in formulating strategies for teaching. Though Piaget claimed to be a genetic epistemologist and was not particularly concerned with
education he was quite clear regarding teaching strategies in his later publications.

"Experience is always necessary for intellectual development - the subject must be active, must transform things and find the structure of his own actions on the object" (1964). Related to this is the importance of the social setting in which the child reacts, the social interaction in a school situation should be an integral element in the process of cognitive growth. Thus development of mental structures through transactional experiences in a social setting rather than the perceptual and concept acquisition through equilibration process (inducing cognitive conflict) rather than learning specific responses through reinforcement techniques should pave the way for constructive and critical thinking irrespective of the subject area studied.