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PSS 6: Teaching of mathematics

PSYCHOLOGY OF LEARNING AND TEACHING OF MATHEMATICAL CONCEPTS

In the first section we discussed how the children conceptualize mathematical ideas and the importance of conceptual knowledge in Mathematics learning; there we illustrated how Mr. Tomar and Mr. Jitendra taught their students about the concept of the n th term of an AP. The pedagogical process used by Mr. Tomar was completely teacher oriented without any scope for students to reflect or question anything. Students were passive listeners and learning become more and more difficult for them. This pedagogical approach is a contribution of behaviourist psychologists. On the other hand the pedagogy used by Mr. Jitendra was completely student oriented and it was due to the active participation of students, they derived the formula of the n th term of an AP. The concept they developed in this way will be ever lasting. The psychological approach used by Mr. Jitendra is 'Constructivism'. In fact as Mathematics teachers we also need to conceptualize constructivism and the way it proposes the progressive development of concepts.

Constructivism, as a theory of learning, believes that each and every individual has the capacity to construct his own understanding and knowledge about various things through experiencing and reflecting. In this process, whenever a child encounters a new experience, he/she can either easily connect it with the existing knowledge or can make some changes in the existing knowledge to accommodate the new experience.

In the following subsection, we can discuss the contribution of three famous constructivist psychologists, viz, Piaget, Bruner, and Vygotsky to the process of cognitive development.

Jean Piaget's Views

According to Piaget, cognitive development is synonymous with changes in cognitive structure, where a cognitive structure consists of several isolated structures, called schemes, that undergo both quantitative and qualitative changes during development. Schemas are the basic building blocks of thought and the mental representation of the objects and events in the world and may be discarded or modified or retained as a result of experiences.

For example, 'number' is a schema, in our cognitive structure from the first standard onwards. How is this schema undergoing modification as one reaches up to graduation level. For a first standard student, it represents any of the natural numbers, when he or she reaches fifth standard, a number may be natural number, may be integers, may be whole number etc.

According to Piaget, one's cognitive structure consists of different kinds of schemas, and cognitive development occurs as a result of changes in the cognitive structure as well as due

to experiences gained during interaction with the physical world. What are the processes involved in this modification process?

Assimilation and accommodation are two technical terms used by Piaget to explain how cognitive structure undergoes modification and improvement. Assimilation occurs when people try to understand a new experience by

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matching it with existing schemas. Accommodation takes place when a person brings about changes in these existing schemas to adapt to a new situation.

For example a student has the concept of rational number. When he/she learns the concept of percentage, he/she will be able to assimilate it into the existing schema. He/she can easily internalise the concept of percentage, by linking it with rational number. Even though both represent different schemas in the cognitive structure, it can be stored in such a way that a percentage is a particular rational number whose denominator is always 100? Through this process, he/she will be able to accommodate the new schema.

Suppose a student assimilates a new thing, which is contradicting or confusing with some schemas already there in his/ her cognitive structure. Then the child will experience a conflicting situation, which Piaget called as cognitive conflict. This will lead to a condition of disequilibrium. As a result of this child will try to find a suitable place for the new schema through a process of reorganisation and restructuring of the previously existing schemas. This process of finding a new place for the assimilated schema is known as accommodation. Through this way, the cognitive structure will become in the equilibrium position again.

In the above example, after introducing the concept of percentage, students may have some confusion since they represent 2% as $\frac{2}{100}$, whereas, they learned as a rational number. This confusion will be cleared when they understand that percentage is a special type of rational number.

Thus, the cognitive structures are constructed and continuously reconstructed through an interaction between the student and various experiences in and out of classroom. As a result of modification in the cognitive structure, more and more concepts will be assimilated and accommodated. Based on his studies, Piaget put forth clearly demarcated sequential stages in cognitive development, namely:

- **Sensory motor period (Birth to 2 years)**
- **Pre-operational period (2-7 years)**
- **Concrete operational period (7-11 years)**
- **Formal operational period (11-15 years)**

Sensory Motor Period (Birth to 2 years) :Children in sensory motor period learn mostly through trial and error learning. Children initially rely on reflexes. In the later part of this period the child will be able to mentally represent the objects and events, and the process is

called object permanence. For example, if you hide a toy at any place in front of the child, the child who has attained the object permanence stage knows the place where it is kept.

Pre-operational Period (2-7 years) : Children in the pre-operational stage can mentally represent events and objects and engage in symbolic play. The typical characteristics of pre-operational children are:

- Able to use symbols (language),
- Engaged in symbolic play .
- Egocentric (view of world from one point of view)

How Children Learn Mathematics

- Thinking unsystematic / illogical,
- Centers on one aspect of object / problem at a time,
- Cannot reverse processes, but has rudiments of conservation and classification
- , • Does not have a structure of whole, but rather many isolated segments.

Concrete Operational Period (7-11 years): During this stage the child

- Can conserve mass, length, weight and volume,
- Able to reverse and decentre,
- Can classify objects (organise objects into an organised schema),
- Logical thinking based on direct experiences.

Formal Operational Period (11-15 years): During this stage child exhibits

- Hypothetical / deductive reasoning (can identify possible solutions to problem solving, can test systematically),
- Inductive reasoning (can move from specific facts to formulate general principles and conclusions),
- Reflective abstractions (can reflect on self/what might happen),
- ability to reason in purely symbolic / abstract manner.

According to Piaget, Mathematics, and in fact, most of the essential schemas cannot be 'taught', they have to be 'constructed' by the child. In the early stages verbal instruction may not help much. Various types of activities, which are essential for building schemas should be included. In understanding a problem the child assimilates it into his/her existing schemas and incorporates into his total cognitive world. When the existing schemas are inadequate to the complexity of the problem, 'mistakes' occur. Then non-piagetian teacher will concentrate

on occurring the mistake. The Piagetian teacher will help to create the condition under which new schema will be created which can deal with the new stimuli. The child studying under a traditional classroom may seem to learn certain things faster by mechanical means. But, the learning of the Piagetian child will be firm and generative and hence in the long run the Piagetian child is likely to overtake the child learning by traditional methods.