

# Helping to Learn Science

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## Abstract

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*The paper discusses in brief the characteristics of children's ideas and how these could be dealt within the classroom, to make learning less stressful and more meaningful. Implications for teacher education are also discussed. This article also tries to explain how teachers should present themselves while dealing with the problems of students.*

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### Introduction

The existence of alternative frameworks or conceptions has been well documented (e.g. Driver et. al. 1985, Halloun, and Hestenes, 1985, Osborne and Freyberg, 1985, Saxena, 1997). It has also been reported that the existence of alternative frameworks creates considerable hindrance in understanding the concepts in depth and to apply them in a novel situation. Sometimes it is found that the children persist with two sets of conceptions, one for academic purpose and the other that children consider their own and use it in personal encounter (Solomon, 1983). Obviously such a situation creates frustration among learners and also among teachers.

### Characteristics of children's ideas

The following are the main characteristics of children's conceptions (Driver and Oldham, 1986, Driver, 1987).

- Students do not come to classroom with a blank-mind-slate but with ideas about natural phenomena. These ideas influence perception, observations and inferences.
- The explanation of a phenomena offered by children may not be same as scientific explanation.
- The language used by children is imprecise, have been found to be similar across countries and cultures, but are not consistent across different situations that are similar scientifically.
- Children's ideas are stable and do not change despite 'education'.
- Sometimes children make inappropriate links with the previous ideas and therefore construct meanings that are different from what is intended by the teacher.
- Children's ideas lack generality and are context-specific.

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The traditional classroom teaching is based upon 'blank-mind-slate' or transmission model and positivist view of learning. It assumes that —

- students come to the class with blank-mind-slate and anything can be inscribed on it;
- the knowledge is with the teacher, is propagated by him/her and is received, interpreted and assimilated by the student in the same form without any distortions;
- a good lecture, therefore, coupled with some demonstrations, etc., is a sure method to improve the efficacy of teaching.

However, we know from experience that this model does not work and a large number of students persist with alternative frameworks despite schooling over number of years (Osborne and Freyberg, 1985, McDermott, 1984, Gilbert and Fensham, 1982). In fact teachers have also been found to contain alternative frameworks (Saxena 1990).

**Common misconceptions found among students**

- A body needs push continuously in order to move with constant velocity.
- Current in a circuit gets consumed.
- When a body is at rest, its acceleration is also zero.
- A part of lens would form incomplete image.
- River and Sun are considered as living bodies.

**Learning as conceptual change**

It may be mentioned that there is a parallel between historical development

of scientific concepts and children's ideas. This similarity cannot be by chance and needs to be taken care while developing the teaching strategy. It requires strategy that lays emphasis on learning as conceptual change. It has its own requirements of epistemology and methodology because science teaching is generally centred on declarative knowledge and ignores procedural knowledge. This needs to be corrected (Gil-Perez and Carrascosa-Alis, 1994). Much work has been done to identify conditions that induce conceptual change. In this context, it is relevant to state model suggested by Posner et al. (1982).

It states that necessary conditions for conceptual change are following:

1. It is necessary to have dissatisfaction with the existing conceptions. One is not likely to change the presently held conceptions until he believes that less radical will not work.
2. The new conception should be minimally understood. The individual must be able to grasp how experience can be restructured by a new conception sufficiently to explore the possibilities inherent in it.
3. The new conception must appear initially plausible. Any new conception adopted must at least appear to have the capacity to solve the problems generated by its predecessor conceptions, and to fit with other knowledge, experience and help. Otherwise it will not appear plausible choice.
4. A new conception should suggest the possibility of a fruitful research

programme. It should have the potential to be extended, to open up to new areas of inquiry, and to have technological and/or explanatory power.

During the last couple of decades many attempts have been made to remove alternative frameworks with varied degree of success (e.g. McDermott, 1991, Rief, 1994, Saxena, 1992, Brown, 1992). Slowly, constructivism has emerged as a powerful approach to help meaningful learning. Dewey is often cited as philosophical founder of this approach. Piaget, Bruner and Anselm have much contributed to its development. Bruner (1990) provides the following principles of constructivist learning:

1. Instructions must be concerned with the experiences and contexts that make the student willing and able to learn.
2. Instruction must be structured so that it can be easily grasped by the student (spiral organisation).
3. Instruction should be designed to facilitate extrapolation and/or fill the gaps (going beyond the information given).

The important features of constructivist model of learning could be stated as:

- Knowledge acquisition is a constructive or generative process and each person's knowledge is personal or idiosyncratic (Fisher and Lipson, 1986);
- Misconceptions may originate as a result of students' interactions/experiences with the real world and/or because of his/her mis-

interpretations of the world of ideas presented to him/her (Driver and Easley, 1978);

- Development of alternative frameworks is from the same mechanism that leads to the development of scientific conception (Bet-sheva and Linn 1988);
- Due to their different conceptual ecologies, different students can 'incorporate' the same new experiences/ideas differently in their conceptual structures/frameworks (Jordaan, 1987);
- The process of concept formation is a continuous process of successive approximation and refinement (Fisher and Lipson, 1986);
- Students hold intuitive ideas that are both identifiable and stable, and have enough commonality to make it worth in planning and instructional strategies (Clough and Driver, 1986).

Constructivism assumes that knowledge is constructed by the individual; he does not mirror what is told or read but the meaning of the information made by an individual depends upon intents, beliefs, emotions and previously held ideas. Effort is required on the part of individual to construct meaning and therefore, learner is responsible for his/her learning. Learning implies reorganisation of prior conceptual scheme or cognitive map.

### **Development of curriculum**

Constructivist approach for the development of curriculum lays emphasis on the questions which are of

interest to the students and the domain of experience that enable the learner to construct knowledge and develop understanding. Curriculum is therefore, not a body of knowledge and skills but a programme of activities. It gives importance to the students' prior ideas and on learning process. One such model has been suggested by Driver and Oldham. It includes five steps in constructivist teaching. The steps are 1. Orientation, 2. Elicitation of ideas, 3. Restructuring of ideas consisting of clarification and exchange, exposure to conflict situations, construction of new ideas and evaluation, 4. Application of ideas, and 5. Review and change in ideas (Driver and Oldham, 1986).

Many teaching strategies have been used to promote conceptual change. It is suggested that teaching for this purpose must include (Hewson and Hewson, 1983):

1. **Integration** of new conception with the already existing conception;
2. **Differentiation** between the existing and the new conception particularly in terms of implications in different situations;
3. **Exchange** between the old and the new conception because they have a different implication that is contradictory;
4. **Conceptual bridging** between the old and new conceptions through a variety of examples, experiences etc.

For effective conceptual change, various strategies have been used. These include use of alternative curriculum (e.g. Saxena, 1992 1993, Lee et al., 1993), use of analogy (Brown, 1992, Clement,

1987), providing laboratory experience, use of concept map (Moreira and Dominguez, 1987). However, sometimes these approaches are not considered sufficient as they do not take into account motivational and contextual factors that may play an important role in actual situation. These cognition-only models may not be effective unless individual's goals, intentions, purposes, expectations and needs are also taken into account. Therefore, there is the need to go beyond cold conceptual change (Cynthia, 1994).

The above mentioned ideas are largely influenced by the theories proposed by Piaget. Vygotsky proposed alternative perspective which is known as socio-cultural perspective. It is believed that human activities take place in cultural settings and cannot be understood ignoring it. The social interactions play an important role in influencing cognitive development. However, according to Vygotsky, the purpose of social interaction is different than as envisaged by Piaget. For Piaget, it creates disequilibrium leading to cognitive development, whereas for Vygotsky cognitive development is facilitated by interaction with a person who is more advanced, be it teacher, peers and others.

#### **Teaching Methodologies that help the learners**

The following could help the learners, if included in class-room teaching:

- Encouraging the students to take responsibility for their learning by providing space for autonomy, initiative and leadership.

- Encouraging students to elicit their ideas, elaborate them and test them in different situations.
- Designing situations that confront the students with their alternative frameworks and provide opportunity for new thinking.
- Allowing wait time after posing questions, challenging students' hypothesis without discouraging their response, providing opportunity to reflect upon their experiences and to make testable predictions.
- Using interactive physical material to allow students to collect data, make observations and draw conclusions.
- Using specific strategies to remove misconceptions such as use of concept map, anchoring and bridging analogy, context specific instructional material, computer assisted learning.
- Drawing from Vygotsky using the strategies such as peer tutoring, peer collaboration, cooperative learning (Damon and Erinphelps 1989, Tao et al., 1999, Tao, 1999) and scaffolding to help the learners with difficulties.
- Use of activity method should not be limited to physical manipulation of objects but should include mental manipulation of ideas.
- Students are permitted to discuss and argue with teachers and peers to test their thinking and get feedback. Communication with others sometimes helps to change the thinking.
- Training in use of assisted learning in the zone of proximal development, collaborative learning and scaffolding as per requirement. Once learning is complete the assistance could be removed.
- Ability to tailor teaching strategy according to students' response.
- Providing opportunity to the learners to find and frame problems, pursue solution by means of their ability and thinking style which encourages the construction of knowledge and negotiation of meanings.
- Training in different methods of identification of alternative frameworks such as paper and pencil test, semi-structured interview, clinical interview, use of concept map and analysis of students' response.
- Exposure to the teachers to the children's ideas so as to appreciate its importance and commonality.

### **Implications for teacher education**

The teacher education programmes require inclusion of the following to prepare more effective and sympathetic to the learners:

- Including conceptual, procedural and attitudinal aspects to increase efficiency to use constructivist approach.

The teacher training could include the following activities:

- Preparation and use of paper pencil test to identify misconceptions and learning difficulties;

- Making of concept map and its use for 1. providing the outline of lesson/unit/chapter, 2. judging the richness of understanding and 3. identification of misconception.
- Organising learner friendly teaching environment which provides flexibility and openness without leading to anarchy;
- Hands-on experience in planning and conducting activities for classroom situations;
- Practice in pursuing procedural knowledge in different situations.

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