History of Science and Classroom of Today
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Typically, photosynthesis finds a place in most primary science textbooks, beginning with statements like "Plants make their own food". This is followed by a list of things they need in order to make their own food, which learners are expected to memorize and churn out in the exam. If we look at the historical development of this understanding, we will find that it came slowly and painstakingly to a series of scientists, who investigated the different variables that impact the growth of plants.

In the early seventeenth century, Jan Baptista van Helmont grew a willow tree in a pot for five years to investigate if water was the source of energy for growth of the plant into a tree. At the end of 5 years, he found that the soil had changed very little, but the tree had increased in weight by 74 kg. He concluded that Water was the cause of increase in mass, and the source of life in plants. In the latter half of the same century, John Woodward tested this finding by conducting a series of experiments done over 77 days. He measured the water consumed by plants, and a typical result that he obtained was: 1 plant showed an increase in mass of 1 gram, while 76,000 grams of water had been added to it over 77 days. He concluded that most of the water escaped through pores: and therefore, it was not the nutrient used by plants! In August 1771, Priestley placed a sprig of mint in closed space with candle and found that the candle first burnt out. Later, when relit, it burnt well in closed space that would previously not support combustion! He drew the following conclusion: Plants somehow change the composition of air. In 1779, Jan Ingenhousz placed a Plant & Candle in a transparent closed space and covered both with a black cloth: he then found that the candle did not light. However, when it was left uncovered: the candle lit up! He thus concluded that in darkness, plants foul up the air like animals, and they need light to purify the air. This laborious investigation spanning a century and a half is compressed in our textbooks to a page or two, at the most, in primary science textbooks.

One wonders: If fifth graders of today are asked to think through the process of plant growth, what sort of route will they take? Of course, we can make no generalizations here, but I will cite one example, drawing from the experience of a teacher in one of the schools run by Azim Premji Foundation.

Niraj is a teacher of science to the primary school students of Azim Premji School, Dineshpur. He was eager to teach in a way that allowed his students to develop scientific temper. He says: "If there is an activity or a principle then we should not give the principle to the child - we should not tell the principle. Earlier, we used to tell them the principle that was in the book, and then we would work more on this." He admits that he was taught in this manner.

He then details out his pedagogy as follows: "So when I was teaching the food chapter, I began by awakening the children's interest. I started with their tastes, whatever they liked. Then I involved their families, their mummy, papa…the things that they liked to do…the new things that are made during festivals….like this, I started. So in this way, many kinds of activities, with discussions, were conducted - so that I did not directly tell them the principle, that something is this way. Through discussion, children began to ask: 'Sir, why

does this happen?' This question came from the children… I did not stop it at all but allowed it to come on its own.

From this, an activity also was started that on Saturdays, children could write their topic-related questions on a chart and they could also write wherever else they wanted. A chart was put up in class and we try to have a discussion on Saturday on those questions and then on that, we talk."

Niraj had to work on sprouts with the children - how germination takes place ... "That was in the chapter on trees and plants….so I started with: 'What kinds of seeds do you see?' Children were to bring seeds from home. So I said, 'You show me. I don't know anything.' So they brought it."

He then proceeded to ask them what was needed to make the seeds sprout.

Children: 'Yes, for this…you require many things… like wind, mud.'

Niraj: "Okay, now what do we do with this?"

Children: 'We will take a cup and put water in it.' A cup was filled with water.

Children: 'Mud will fall into it.'

Niraj: "Will mud fall into it? Okay."

Another child: 'Sir, this can work without water… keep some wet cotton.'

Niraj: "Shall I put some water or shall I keep some cloth?"

Children: 'There is some cotton, we can even keep some cotton, or some cloth.' So they kept it on the window sill, in cotton.

Niraj: "We will observe what happens … in your copy, make a column…and whatever you feel is the observed difference in the seed…make a picture…next day what happens, note down your observation…in the picture."

This went on for three or four days, till it started to sprout, when Niraj saw that, the children were puzzled as to whether or not soil is really required. Here, they had seen it sprout without mud. So there was quite a lot of discussion, and the experiment was repeated….when children finally confirmed that without soil also, sprouting can take place. So then two groups formed: one claiming that without mud sprouting cannot take place, while the other declared sprouting can happen in the absence of soil…

The former group claimed that cotton gave out heat and thus did the work of the mud…mud also gives heat and in this way the sprouting took place.

Promptly, some children said, 'Alright, let us remove the cotton.' Then another child said, 'But it requires light.' [The bowl had been kept on the window sill, with light falling on it.]

Niraj: 'What should we do?'

Children: 'For now, we will take this bowl away from the sun and keep it behind the almirah and also we will remove the cotton…'

Interestingly, Niraj points out that this suggestion came from the children through discussion. Children also came up with interesting hypotheses like: "Sir, cotton is also from the tree and the tree is in the mud so all the important qualities (gunas) which are there in mud somehow reach up to the cotton…"

Then the sprouted seed was covered with a cloth, even then some children said, 'Sir, light can go through if the cloth shifts,' so it was kept it behind the almirah in a place where the sunlight doesn't fall. When sprouting happened with that, too, then children had more questions…and the discussion intensified.

Children: "Sir, the water already comes from the ground, so the water which comes from the ground has absorbed the elements which are in the mud….'

Other children: 'Sir, since we take seeds out of the mud, a little mud is on them, or it has fallen on it, in the water.' Of their own, the children refined their experimental design by insisting that there should be no mud on the seed or in water. One child said, 'No, Sir, in this water there was absolutely no mud and we had also covered it so there was no dust either.'

Other children countered: 'How can you definitely say that there was no mud?' To which came the answer: 'The water that I brought, actually was from the RO…so it was fully filtered water….'

With deeper discussion, children understood that without soil, sprouting can take place, but for seeds to grow into plants, then trees and progress further, soil is required. Niraj confesses: "So I tried to make children do, see and learn to question. In this way, they should reach the principle by themselves, instead of us telling them that these things are required, and they just accept it. Children are asking questions, then discussing….so because of that somewhere there is a curiosity, they are doing and learning. Secondly, they do not believe something straightaway, but they are seeing for themselves, and only then do they believe. Secondly, if they have a question, they are able to place it and they are able to satisfy their curiosity." He admits: "Earlier I used to teach in the previous school, we used to make them do experiments and other types of activities we used to do…but this kind of pedagogy…it is a first experience that where my effort is that children reach a principle by themselves."

Interestingly, Niraj was totally unaware of the historical development of photosynthesis: but it was remarkably replicated in his class!

Note: This article appeared in Azim Premji Foundation's internal publication titled INFOCUS in February 2014