Good Medicine - Bad Science Teaching

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Are our schools doing a good job of teaching science? Here is a conversation I had with some of the country's top science students at a National School Science Exhibition. It gives some insight into the question of what we mean by scientific literacy.

One group of students had done a very interesting science project on certain kinds of medicines. They had samples of the medicines on display. Information about the medicines was nicely presented on posters in good English, and they had written a lengthy report in Hindi as well. It was impressive.

After looking over some of what they had written, I asked them, "How do I know if this medicine is good?"

"I'm telling you it is good. You can believe me," one boy replied.

"And how do you know it is good?"

"Because that man told us," he said, pointing to a photograph of a man on their poster.

"And why do you believe that man?" I asked

"Because he said there was a woman who had kidney failure," another student replied. "Both kidneys were failing. She took this medicine and she recovered."

"Okay. One woman recovered after taking this medicine. Good. But how do I know what would have happened if she had **not** taken the medicine? Maybe she would have recovered even without the medicine," I ventured.

"No. She would have died. Unless she could have gotten a kidney transplant she would have died."

"How do you know? She **took** the medicine - so how do you know what would have happened if she **hadn't** taken the medicine?"

"She would have died. Her Medical Report said she was going to die."

"It was a MEDICAL REPORT," another student explained. "It was written by a DOCTOR!"

"But suppose the doctor was wrong?"

"No, it couldn't be. Look, you can **believe** me, this medicine is good," another boy pleaded.

"I will believe you if you can convince me. Try to convince me. Give me some good reasons. You say one woman recovered after taking the medicine. But how do I know how many people did **not** recover after taking the medicine? Should I be convinced after just one recovery? Suppose you were scientists. What would you do to find out if the medicine was good?"

It was clear that these were exceptionally good students who had done a lot of hard work and had found out a lot of information. They had been chosen as representative of the best science students in the country. But had they learned **science**?

It seems they had very little idea of what the **scientific method** is. They did not realise that they should raise questions about things they read in books. Science is all about raising questions and doing experiments to figure out the answers to questions.

Science is not just information and definitions. Following the scientific method, we observe, raise questions, and make hypotheses about how and why things are the way they are observed to be. We make theories to explain the world around us. We make predictions based on our theories. We design experiments to check the validity of these hypotheses. After carrying out the experiments we analyse the results and draw conclusions. In the process of doing the experiments, new questions and problems arise. We may have to modify our hypotheses and theories. We then design new experiments in the continuing process of scientific enquiry. It is this process of discovery that makes science exciting and meaningful.

The scientific method is not just a highly sophisticated process that can only be undertaken after years of formal study, foreign degrees, or post-doctoral experience. Take a look at the way young child learn and you can see that they often follow a scientific method, although usually without being fully aware of the process they are following.

For example, suppose a young child notices a strange new object on the ground. She is not sure whether or not she just saw it move. From her past observations, she knows that similar things that moved were living animals – small bugs, for example. She wonders whether or not this is a tiny living animal. Based on her past observations, she forms a hypothesis that living animals move, and that this thing moves, and therefore is living. She does an experiment to see if her hypothesis is correct. She watches it for some time to see if it moves. She finds that it does not move. But she questions the validity of this test and decides to poke it with a stick to see if that will make it move. She has chosen this approach based on past observations that living things move when they have to escape from dangerous situations. But when she carries out this experiment, the result is that she inadvertently smashes the thing with her stick. She concludes that it may have been a living animal, but it was killed by the stick, so that is why it no longer moves. At this point her father comes along, sees the object and tells her that it is just a piece of wood. However, she questions this, and decides to look for more such objects on which to conduct further experiments.

Compare the learning process of this young girl to the way students learn in schools. These days even the best science students often lack a questioning approach to their subject. They are too ready to believe something because they read it in a book or hear it from a teacher or other respectable adult.

The group of students I talked to in the Science Exhibition seemed to believe that if something is written in an official document like a Medical Report, it cannot be questioned. They also had no idea of how or why scientists use a **control** when they do an experiment. For example, scientists might give one set of patients a medicine and another similar set of patients (the control group) will get no medicine. Then they will compare what happens to the two sets of patients in order to find out the effect of the medicine.

The students also did not seem to have thought about the unavoidable errors that occur whenever anyone makes observations or takes measurements. They didn't know that more than one observation is needed. This is something that the young girl investigating the object on the ground **did** realise, although unconsciously. Perhaps she had not yet been subjected to enough adults telling her to stop exploring and believe what they say without questioning.

What happens when such a child goes to school? Does the education children receive in school encourage them to ask questions, explore their world, experiment, and further develop their scientific ways of thinking? Does it help them to become more conscious of the scientific method? Does it help students develop their ability to analyse and solve real-life problems?

Or do schools teach children to loose interest in scientific discovery and unquestioningly accept the voice of authority? I wonder if this is what we really want to be teaching students. Is this what the government means by education? Perhaps.

This is a photograph taken at the event - part of the 91st Indian Science Congress in Chandigarh

Chemical composition of distilled cow urine:

1. Nitrogen (N2, NH2): Removes blood abnormalities and toxins, Natural stimulant of urinary track, activates kidneys and it is diuretic.
2. Sulphur (S): Supports motion in large intestines. Cleanses blood.
3. Ammonia (NH3): Stabilise bile, mucous and air of body. Stabilises blood formation.
4. Copper (Cu): Controls built up of unwanted fats.
5. Iron (Fe): Maintains balance and helps in production of red blood cells & haemoglobin. Stabilises working power.
6. Urea CO(NH2)2: Affects urine formation and removal. Germicidal.
7. Uric Acid (C5H4N4O3): Removes heart swelling or inflammation. It is diuretic therefore destroys toxins.
8. Phosphate (P): Helps in removing stones from urinary track.
9. Sodium (Na): Purifies blood. Antacid.
10. Potassium (K): Cures hereditary rheumatism. Increases appetite. Removes muscular weakness and laziness.
11. Manganese (Mn): Germicidal, stops growth of germs, protects against decay due to gangrene.
12. Carbolic acid (HCOOH): Germicidal, stops growth of germs and decay due to gangrene.
13. Calcium (Ca): Blood purifier, bone strengthener, germicidal.
14. Salt (NaCl): Decreases acidic contents of blood, germicidal.
15. Vitamins A, B, C, D, E: Vitamin B is active ingredient for energetic life and saves from nervousness and thirst, strengthens bones and reproductive ingredient for energetic life and saves from nervousness and thirst, strengthens bones and reproductive power.
16. Other Minerals: Increase immunity.
17. Lactose (C6H12O6): Gives satisfaction., strengths heart, removes thirst and nervousness.
18. Enzymes: Make healthy digestive juices, increase immunity.
19. Water (H2O): It is a life giver. Maintains fluidity of blood, maintains body temperature.
20. Hipuric acid (CgNgNox): Removes toxins through urine.
21. Creatinin (C4HgN2O2): Germicide.
22. Aurum Hydroxide (AuOH): It is germicidal and increases immunity power. AuOH is highly antibiotic and anti-toxic.

- Increases resistance power of the body.
- Increases life span and purifies the blood.
- Effective for all kinds of diseases.
- Restores balance of the "three doshas".
- Reduces fat.

This is from an advertisement in which someone on the internet is trying to sell “distilled cow urine”. According to the advertisement, it seems to contain all sorts of things. And it seems to be a real ‘cure-all’... But why not investigate it using the scientific method? Doesn’t distillation remove most if not all of these chemical compounds from urine? And what is the evidence that it really works as advertised?