Phenomena-based Science as Empowerment

There are a variety of ways in which our presence on the earth leaves its mark. In terms of advancing science, one way is through our written work, but another is through the human interactions in teaching or otherwise that can inspire others to look at science, or life, in new ways.

As have many others, I received such a gift of inspiration while studying in the *Naturwissenschaftliche Studienjahr* at the Goetheanum with Georg Maier and Jochen Bockemühl in 1984-85, for which I am most grateful; and through a chain of circumstances this has led their work to indirectly enrich the lives of many children and adults in rural South Africa longing for an approach to science that truly empowers.

When I came to Africa as a volunteer teacher in 1997 everything was different from what I had expected, which bore the potential either for great disappointment or for a new beginning. As it happened, the principal of a rural farm school was very interested in science, and when I mentioned having used a shiny spoon as a convex / concave mirror he was thrilled: This was something everyone could do – but in the schools he knew it was not done. Schools for underprivileged black children did not only suffer from a lack of equipment, they suffered from a lack of ideas. Through this the *Nkonjane Trust Schools Outreach Project in Phenomena-based Science and Mathematics,* NTSOP for short, was born, and eventually the one-year volunteer commitment grew into a very enriching three-years of conducting workshops and school visits for hundreds of teachers and thousands of students. The guiding thought was how to bring science experiences in a way that could be meaningful, memorable, and true, and with an eye towards understanding the basic principles of the telephone, the electric motor, and the AC power system, all of which were either brand new in the lives of the children or were going to be part of their environment and lives soon.

The actual work presented in workshops and during school visits consisted on the one hand of very simple experiments that were easily replicable using commonly available household materials like matches, candles, paper cups, string, paper clips, nails, batteries, and insulated copper wire, and on the other hand of some important but more sophisticated complementary experiments. It is one of these more subtle experiments, inspired by Georg Maier, that I would like to share on this festive occasion.

The experimental setup consists of a hand-cranked AC generator from an old telephone, a 110V/7.5W light bulb, a 3 or 4-cell (4.5–6V) flash light bulb, 500 meters of two-strand indoor telephone wire, wire leads with alligator clips, and a dissectible transformer with a primary winding of 2500 turns and a secondary winding of 150 turns. Instead of the dissectible transformer I have also used a transformer from an old microwave oven, which works fine as well.

The first part of the experiment involves having a student (or other volunteer) crank the generator, first without load, and then with the 7.5 Watt lamp connected. Usually the student is surprised to realize that he or she can tell when the lamp is turned on even with eyes closed – the crank becomes harder to turn. This can later lead to a conversation on why it may be a good idea to turn the lights off when nobody needs them, why electricity costs money, and why houses have electric meters.

Next the 110V/7.5W light bulb is removed and replaced with the flashlight bulb. Although the crank gets harder to turn, the little light bulb does not light up (this is done only for a moment, so as not to burn out the wires in the generator). Here lies an important aside: With electricity it is not just a question of "more" or "less", it has to do with proper conditioning. To make the point, I sometimes call my transformer an *electricity conditioner*, because as soon as the transformer is properly connected to the generator and to the flashlight bulb, the bulb lights when the crank is turned (with resistance).

Of course nobody would want to live next door to a dirty and noisy power station, so as a further step we connect the 500 meter long two-strand wire between the transformer and the flashlight bulb. Great disappointment ensues, as the bulb no longer lights up at all, or only very dimly. What can we do ? The trick is, of course, to move the transformer to the other end of the wire, next to the flash light bulb, which now lights up just fine, just as if the 500 meter long wires were nonexistent. It is amazing – the exact same components are used both times, but with a slightly changed geometrical setup the outcome is totally different. Previously, the 500 meters of wire seemed a formidable challenge, but now this is no longer a problem. When reviewing the experiment the next day, it can be pointed out that one can *always* find a transformer close to the end user.

One reason for presenting this sequence of experiments has to do with common misconceptions about electricity. They may not be misconceptions for a research scientist, but they surely are for the general population. A typical example is the science book for children that displays a battery, a lamp, and two wires connecting them, and then states that it is the electrons that make the lamp glow. Of course there is no experiential basis for a child to come to this "conclusion". In a similar vein, many people seem to believe that we buy electrons from the power company, just as we buy water and gas from our utility companies or municipalities. When there was a power crisis in northern California a few years ago, the Governor was quoted as saying that northern California had a problem because the electrons could not get from southern California to northern California …