CAN CIVILIZATION ADVANCE WITHOUT SCIENCE EDUCATORS

Galileo never dropped two cannonballs of unequal weight from the Leaning Tower of Pisa. Long before, a Paris school of philosophers had convinced the academic community that Aristotle’s idea (that heavy objects fall faster) was wrong. The Paris argument was a thought problem:

Simply imagine that three objects of equal weight begin falling together...at equal speed of course. Now, in mid-flight, join two of them together so that the two become one double-size mass. Will it speed up? Now cut this new connection. Will the race of acceleration now slow down?

To all who listen to this thought problem, the "intuitive" answers were no, the rates would not change as the objects were joined and severed. So, a thought problem, and not Galileo's mythical Leaning Tower of Pisa experiment, rejected the idea that heavy objects fell faster. (Bronowski & Mazlish 1960) (This is not to deny the critical role of experience and experimentation in science—a person without falling objects in his/her experience would find nothing incongruous about objects changing their acceleration. The thought problem, like experimentation, ultimately relies on real world experiences.) I would now like to propose two thought problems that I believe "prove" that science educators are the key agents propelling civilization forward and that science researchers, while very important, must patiently wait for science educators to do their job first.

I

In the first thought problem, I would like to send a modern day person back to the time of the U.S. Civil War and provide this time-traveler several hours to convey just a few of the techniques and practices that make modern medicine so effective. We can't convey the whole modern medical curriculum but perhaps we could give these early doctors a big boost by targeting just one set of ailments—perhaps respiratory diseases.

Doctors of the mid-1800's didn't do surgery in the chest area. They would mend broken limbs and dress wounds but most felt that the chest and abdomen would always be off-limits to surgery. Coughing, sunken chest area, rasping breathing sounds...all were pigeon-holed under the catch-all term of "consumption." "Change your diet...move to a different climate," that is all they could prescribe.

Today, what was called "consumption" is recognized as dozens of specific diseases: tuberculosis, viral and diplococcus pneumonia, emphysema, asthma and allergies, silicosis and "black lung," tobacco-smoking induced cancers, etc. If you could help them distinguish just these few modern diseases they could make enormous strides in curing the ill during the rest of the Civil War!
Are you ready to travel back in time? Grab a medical book and strap yourself in! We seal up your capsule and ZZZAP!

Well, there you are in the midst of a conference of General Grant's medical officers. We've dressed you right, your modern accent is still understandable, and you have their attention so go to it!

"Gentleman, the disease you now know as consumption can be better treated when broken down into finer categories. If you detect rod-shaped bacteria in the sputum of patients that cough, and the bacteria are fluorescent-positive, they have "tuberculosis"... (Hmmm, the doctors are puzzled. Of course, they don't have such dyes! Come to think of it, they haven't heard of bacteria causing diseases yet. And few microscopes are yet powerful enough to examine bacteria.)

"Let me start by saying that there are disease organisms all around us, on all surfaces and floating in the air. If you take a Petri plate of agar media... (Ooowps. Robert Koch didn't develop culturing techniques like that until 1880. Hmmm.

"Well, not all lung diseases are bacterial. Viral pneumonia is caused by infection, by a..." (Well, we had better not get into nucleic acids, now, had we? Not even Pasteur understood his 'filterable' rabies agent, and he was more modern than these gents.)

"Now, some of our patients are developing an allergic response to such environmental particles as pollen and..." ( "Allergic?" These doctors are still suspect of night air 'miasmas' for cholera and malaria... how can you begin to explain histamines?)

"Well, sometimes cells and tissues grow wildly out of control. This is called cancer, and can be caused by damage to cell genetic material by particles of asbestos or tobacco smoke..." (Finally, the medical crowd bursts into laughter. Puffing on their pipes and stogies, they have finally concluded that you and your jibberish are mid-war comedy relief!)

As you climb back into your time machine, you can even ponder if leaving behind a modern medical text will have any good effect at all—it too is "jibberish." The medical words, the advanced concepts, all are meaningless unless you can take each listener and carry him or her through the experimental regimes that make "bacterial culture" and "immunity," etc. meaningful. Instead of grabbing a book when you entered the time machine at the start of this venture, maybe you should have grabbed a sackful of laboratory equipment!

And how long would it take to lead all those 1860's doctors through 125 years of medical advancements? And what about the patients who describe their ailments in unenlightened terms of "the grippie," etc. and have no concept of "germ theory" that would allow them to carry through with the prescriptions and
hygienic procedures an enlightened doctor would prescribe. It just might take 125 years of teaching doctors and the public at large to bring them up to our present day level of health care.

II

Well, we are back at the present, and I would like to take you on another thought problem, this time with that modern day miracle-worker, the computer. In this thought problem, we are going to build a computersized experiment-generating experience-gobbler, an E Geg (pronounced 'egg-egg')—an "electronic scientist."

We will put wheels on our computer, and a power pack so it can go anywhere. Add a full supply of environmental sensors and manipulators, cloud chambers, test tubes and reagents, and every other test device known, so it can detect everything in its environment and run little tests in the real world. Call this its "interface." Give it lots of memory to store models and simulations—a "metaphor supply" (Schrock 1984).

Now, let's crank it up, set your foot on the running board, and pull on the starter cord ....BBBBBBBBBBBBBB! It's off and running!

Our E Geg heads off down the hill, slope calculated, wheel friction measured, speed confirmed. No new concept needed. The E Geg pauses, measures dewpoint, checks adiabatic rates, and predicts cloud ceiling. The E Geg's little crystal eye and radar confirm the cloud ceiling is just where predicted. No new concept needed there either. Now it has wandered into a flower patch and a patch of unanswered questions. The E Geg is working in a frenzy! Its experiment-sector is clinking with micro-tube analyses of flower pigments. The metaphor bank is constantly lighting up as it is consulted for possible models. WOW.
The EEGG is pushing the frontier of knowledge forward at a tremendous pace. Each time it defines a new concept or accounts for previously unaccounted-for variation, it burps out a "discovery card" with the name of the new concept.

--- plant pigments only correspond to old plant phylogeny by 0.62.
New EGG phylogeny formed with 0.98 correspondence.
--- unknown selection factor for upper light spectra now 86% explain by EGG new term "sipholization"
--- 80% of remaining 14% unexplained by sipholization fits new EGG model of "ultracanterization"
--- flower non-target insect repellance 92% explained by new EGG term "streblification"
--- etc., etc., etc.

Like Hansel and Gretel leaving a path of breadcrumbs as they journey into the dark forest, our little EGG merrily experiments its way into the future, burping a trail of new concepts for us to follow in its path.

But wait! What exactly is sipholization and ultracanterization and streblification? We cannot be handed tomorrow's wisdom "ready-made." The only way we can know these advanced concepts is to be handed the definitions as well. And the definitions are understood by us and are useful to us only if they are defined by experiences, just like the very experiments that permitted their "discovery." It is not enough for the EGG to be a super-scientist researching off into the future. If the EGG isn't a super-science educator that can explain each step it has taken in experiences that we (as well as the EGG) know, all of that advanced "learning" (if we can call it that) is lost to us.

Well, wave goodbye to our wonderful EGG as it discovers the world for itself. Here we still stand in modern ignorance. And so conclude our second thought problem.

Of course, the two thought problems really address the same issue. In the first case we have superior knowledge which we cannot transfer back to a time that lacks the experience base to understand it. In the second case, we long for the advanced knowledge of the future, but again lack the necessary experience base to understand it. To most of us, this reveals something quite new. We have always assumed that the advancement of civilization depended upon the pace with which we educate our populations. And by "educate" I mean provide them with experiences so that common persons' minds "image" bacteria and not miasmas in the air, and allergies and cancers in lungs, and not "consumption."

The speed with which we, as science educators, do our job even determines the extent to which our best scientists can reach out in new research. Leonardo da Vinci was chained to the resources that were available to him in the late 1400's. Think what he could have done if born into an age with advanced alloys and
plastics. How much more could Einstein do now than 40 years ago? But it took time for us, as science educators, to spread the knowledge to those who would develop the technology, and especially to make "parachute" and "military tank" and "cyclotron" common everyday words among a populace that agrees to support such research with its taxes.

So, does civilization rest upon the shoulders of the science educator? Civilization certainly doesn't advance as a modernization of gladiatorial events, although you would deduce this from the newspaper space devoted to sports. What about art and music? "The great ages of art in the West are in Greece, and Italy in the Renaissance, and the England of Elizabeth and the Restoration. Those were also the places that were technically most advanced, most inventive, most excited by the adventure of progress. And people lived better there, ate better, had better tools than anywhere else in the world as it was then." (Bronowski 1962) It appears that both music and art follow in the wake of scientific discovery and are proportional to the resultant changes that science brings.

Before we give scientists the main credit for prodding civilization along an upward path, consider that if scientists kept all that new understanding to themselves, we wouldn't be any better off. And, scientists know that their work would soon come to a standstill, "choked" by the sea of ignorance around them. This is what imbeds communications in science. Scientists have to communicate with each other, and they have to communicate with the rest of us so that, in the case of medicine, their discoveries can have the fullest effect, and so that technology can move to the point where there are new materials and new instruments to use in research.

Today it falls on "science educators," those of us who specialize in communicating science, to update everyone's images of the real world and to recruit new young researchers with new imaginations. It would appear to be the speed at which we are permitted to work that in the end determines how fast "civilization" progresses.

Remember, our newest medical research couldn't help the Civil War doctors, and tomorrow's discoveries will be jibberish on the street—without science educators. We are really most important.

REFERENCES


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