



Title: The Need of Sensitivity in Science: As the foundation of Cross-Cultural Science Education

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THE NEED OF SENSITIVITY IN SCIENCE:

---As the foundation of
Cross-Cultural Science Education---

"Science sets forth this formative process in all its detail and necessity, exposing the mature configuration of everything which has been reduced to a moment and property of Spirit. The goal is Spirit's insight into what knowing is. "

[Hegel: Phenomenology Of Spirit. 1807.]

1. That what we usually think as "Science" is "Power Science" and lacks Sensitivity.

The image of Powerful Science bulldozing through problems and resistances to get things done is very strong in our mind. And, therefore, it is hard to talk about "Sensitivity" as an important element in Science.

Occasionally we do talk about beauty, poetry in science, such as Fabre's *The Diary of Insects*, and Einstein's *Cosmic Vision*. But, I am afraid, we tell such stories as "diversions" from the main instructional materials. Perhaps we tell more jokes of dubious value to entertain students more frequently than telling about the "sensitive" tender elements in Science.

By and large we treat the sensitivity in Science as of secondary importance. As a consequence, teaching practices of Science tend to be that of imposing the Powerful Science on the minds of students. We may not be conscious of us doing that. But if we step back and look at our practices, it appears that we are teaching Power side of Science almost exclusively and neglecting Sensitivity side.

I think it is unfortunate, for the creative thinking, the sensitivity is essential. Even if the majority of human population has to perform mechanical routines to make a living, our children deserve an educational period where they are treated with the delicacy of the Sensitive Science. For that reason, I would try here a "scientific explanation" of

the Sensitivity, is a rational to stress the importance of it in Science. I hope, my explanation is sufficiently general to encourage Sensitivity in human life in general.

And, I have a feeling that what I meant by Sensitivity also has some meaning to the Cross Cultural Education. Since I am not familiar with the Cross Cultural Education that experts here are engaged, I do not make a claim. Rather, I would like to ask you if what I am going to discuss here has any relevance to the Cross Cultural Education. I would be grateful if you kindly give me back responses and reactions to what I said.

2. Where can Sensitivity be located in our Intelligence?

In order to introduce the Sensitivity, let me talk briefly about "Science" in general. To save time, I present a simplified archeological diagram here.

Science is a part of human intelligence to use the faculties of our brain/mind.

- (i) The first level of intelligence on the surface is Object Recognition level. This is what Atomism does. We recognize objects and identify them. We sometimes decide to ignore things as well at this level.
- (ii) The second level is Relation Recognition level. There we think of relations between Objects. Statistical Correlations, Causal linkages may be recognized and identified. Basically, the relations recognized are of the "Linear" kind. [*See Subnote 1.]
- (iii) The third level is Utility Recognition level. We sense what we can do with the objects and relations we recognized.
- (iv) The fourth level is Strategic Construction. This is often referred to as "Problem Solving" intelligence. We take the situation at hand as the starting point, and see the desired state as the final point. If we find "The Means" to connect these two points, we call it "The Solution" of the problem.

As such, the fourth level resembles the second level, except that the "Connection" (Relation) is imposed by us. And, often times, the task of finding the "means" to connect the two points is accomplished by ignoring and cutting off relations that existed. The image for this "problem

solving" is Alexander The Great cutting a knotted ball of string with a sword in one blow. The sword is the imposed connection cutting through all pre-existing relations. Unfortunately, this happened too many times when a powerful dominant Culture met others.

In these 4 levels, there is no need of the Sensitivity. Rather, we would think of the "Minimum" that is necessary for what is desired. We deem that is "Efficient" and "Rational" within the contexts considered.

For example, we recognize two towns on both sides of a mountain. That is at the Object Recognition level. We see people going back and forth between the two towns. This is the Relation Recognition level of thinking. We see the Utility of the exchanges. And we Bulldoze to make a Highway between them and think that the problem is solved.

The "Science" in our ordinary sense is an organized and formalized "knowledge" at the above 4 levels of intelligence. It empowers people in that sense. Let me call this Power Science. It lets us do things. But there are levels below this, if we dig into our minds deeper.

(v) Although we seldom think any deeper than the Power Science levels, we occasionally do "Think Twice". We ask whether or not the construction of the Highway was a good thing. Let me call this 5th level intelligence as the "Reflective Level".

We do have this intellectual capacity to "Think Twice" about what we have done, and also sometimes what we are about to do. That is where the Sensitivity comes in. Although we have the Power to do and to get a certain thing that we desire, we ask ourselves if doing so might not hurt someone. We exercise a care to protect other's safety, interests, wellbeing. This takes a fair amount of imagination as to the situations that we are about to create.

This requires thinking of the whole system of things in a complex web of relations. It is different from the kind of thinking of Power science which can be metaphored as that of "Drawing a line from a point A to a point B". For, in the complex web of relations, there are lines from the point B to the other point C, which in turn relates to other points. All linked in that sense, the circle of the linkage most likely comes back to the initial point A. That complicates the situation. A straightforward thinking is only applicable

to linking nearby points. The whole circle of relation is not "straightforward", but rather "Non-Linear". That makes thinking very hard.

[Linear/ Non-Linear distinction is explained in Subnote 1.]

But the strange thing is that Humans do have an intuitive sense by which they can "Feel" the harmony or disharmony of the whole system. Even in highly theoretical works, physicists often came to "Feel" the whole thing and said it is a "Poetical Beauty", or "Poetical Unity".

That is the "Care" that one exercises to understand the whole of the cyclic relationships and the "Beauty" that one feels about the whole are related.

I think it is highly desirable that children are given the opportunity to experience the "Care" and "Beauty". It requires Sensitivity to experience it. But the Sensitivity cannot be developed without experiencing it. I think this is a great challenge of Science Education.

I would like to suggest that Science Education has to aim at the caring level of intelligence. And I think it is possible to lead students to that level by asking them to "Think Twice" as often as possible. The Science Education has to contain exercises for saying "I can do this But on the other hand..." Such exercises are training for Sensitivity.

We might call this "The Sensitivity Science Education", in a contrast to the "Power Science Education" that we have been doing.

And I hope that they enjoy seeing the "Beauty" attained after many exercises of "Thinking Twice".

3. The Sensitivity Science is a "Pragmatic" necessity for Human Survival, and Cross Cultural Science Education is a beautiful way of the Sensitivity Science Education.

In view of what we are doing nowadays to our Environment and to our fellow Human beings, I would say that without Sensitivity, we will not survive the 21st century. For the sensitive eyes, the bad consequences of the Power Science are visible almost everywhere. Even if we do not want to see them, things such as Acid Rains descend

upon us. Incidences such as Chernobyl happens and force us to know what we are doing to ourselves.

In the line-like thinking of Power Science, we do not see the remote consequences of our actions. But the fruits of our deeds loop around and come back on ourselves.

In that, I am not a Romantic Idealist to advocate the Sensitivity Science. I have a "Pragmatic" concern about the future of the World in which our children live or die. Either we educate ourselves and change to become Caring Beings, or we annihilate ourselves. It is not possible to evade the choice.

Fortunately, however, we have a marvelous educational opportunity called Cross Cultural Education.

It gives very good opportunity to Think Twice about the Power Science that our dominant Culture has been practicing up to now.

The Cross Cultural Education is one way of giving our children the opportunity, and a beautiful way of doing the Sensitivity Science Education. Here, remarkably, we have a consistency of the means and the aim. We have the way of studying which calls for Sensitivity. And we have the aim that is the Sensitivity.

I look upon Cross Cultural Education to be not a "Tokenism" to satisfy disgruntled minority races, or "Window Dressing" to soothe the "Guilt" from the colonial oppressions and the racial discrimination in the historical past. But I consider it as a Golden Opportunity for every one to learn the way of Survival and at the same time the way of constructing a beautiful Future.

Beyond that, I would like to stress here that this is not a subject of "social studies", but of "Science".

I am not saying this because I am a scientist and wanted to externalize the power of science. You must realize that I am a "scientist" only in the Power Science. Among other things it was the prejudice of the "Power Science" that used to say that Euro Americans have the Science.

And, I have to learn Cross Cultural Science for my own sake. And people here are great help to me. I wish I could go back to school again and experience beautiful education that you are doing.

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I add one, perhaps, "Bad" example for the advocacy of Cross Cultural Science Education. It is from General Relativity.

General Relativity can be viewed as an "art" of how to connect a small local Linear way of thinking (analogous to making a short sentence) to the next. The connections of many small Linear descriptions (analogous to a whole "story" made of many sentences) make up a Global Geometry which may be "Non-linear". General Relativity is concerned with the Whole of the Global Connections. Needless to say, to make a comprehensible coherent picture is not a trivial task. Some constructions are beautiful, some are ugly.

The "connected whole" is a "World View". And among many ways to make up the "connected whole(s)", we can study how to compare various ways of making "connected wholes". In this sense, General Relativity is interesting. It resembles "Cross Cultural" learning.

However, as I said before, General Relativity is "perhaps a bad example". The trouble with this example from modern physics is that it is by and large inaccessible to the general public.

There are "popular books" such as The Turning Point by F. Capra etc. However, ordinary Science Education does not come anywhere near to the "Way of Thinking" contained in those modern developments in science. Schools, perhaps unconsciously, teach the 300 year old physics and waste time in "beating the established mechanical routines into blank minds of children" under the name of Science Education. It so happens that the Old Science also carries the Authoritarian Ideology of that particular culture.

It also represents the "Alienated" mentality of the 19th century European Intellectuals. [see] M. Berman. The Reenchantment of The World.] That Science emerged in the 17th century as a "Liberation of Thinking" is largely forgotten and perverted, under the disguise of "Rigorous", "Exact", discipline.

Psychoanalysts ought to examine why so many scientists and science teachers today still maintain the illusion of "rigorous, exact science" as if they have never heard of the Uncertainty Principle or Godel's proof of Incompleteness of Mathematics. Their quasi-religious belief may be within the Freedom of Belief allowed by the Constitution, but the Authoritarian posture of scientists talking down to the

public, as if they are the guardians of the Absolute Truth, is a pedagogical disaster in barring the majority population from access to the modern science.

That I have a considerable difficulty in talking about fruits of the modern science in terms of "Ways of Thinking" attests to the failure in Physics Education for which we physicists are collectively responsible. We have spent Hundreds of Billion Dollars of tax money, but we have not helped society with cultural developments in terms of the Ways of Thinking. The public money is used to edify a small group of specialists and widen the gap of thinking inequality, not mentioning the North-South disparity in science-technology and wealth. We ought to think, for example, why we do not use science to make rudimental water supply systems available to the poor half of Humanity. It could be done at a fraction of the cost of sending a school teacher to Space and getting killed in a Show of National Superiority. I do not think it is excusable.

One very inexpensive way of introducing New Way of Thinking to general public is to do Cross Cultural Science. Since most of the "Sciences" from different cultures are accessible through non-technical expressions, they are better suited for general Education. (I fancy that "Hopi Relativity" is just as good in conveying the main idea as General Relativity which is accessible only through complicated mathematical manipulations.) That is to say, we have discovered a mountain of treasures in the Native Science. I recommend school teachers to seriously look into Native Science and take advantages of the treasure.

(However, I would caution the teachers to pay proper respect in exchange, lest be accused of stealing the last and the most precious treasures of the Natives after taking everything away from them. One way of expressing respect is to invite Native Scientists and let them speak, rather than giving an "Interpretation" to students as if that is genuine Native Science. And if possible, let students learn from the way the Natives live with the "Science in their actual life, rather than substituting an "intellectualized version" for it.)

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My story here was perhaps tedious and technical and it was from the background of the Power Science. But I hope it is of some help to you.

Thank you for your patient listening.

[Subnote 1. On Linearity.

"Linear" means "line-like". When relations between pairs of two quantities, such as "Input and Output" plotted on a graph paper appear like lines, the relations are called Linear.

Most relations in Reality, however, are not Linear. Why, then, do we favor Linearity? The most theories in science are Linear ones. Economists use Linearized models; Political Scientists and Politicians talk and think in Linear Language. We usually think Linear, such as if something is good, then more of it is better. It is not rare that sick people take more pills, thinking that the more pills he or she takes, the faster the cure is, then ends up with an Overdose. Or a man who makes hundred thousand dollars a year thinking that he would be a twice bigger man if he could make \$200,000 etc.

But, the worship of Linearity is not just silly superstition in numbers. There is a definite advantage in Linearity. I cite an example.

Suppose a psychologist or social scientist is faced with an unknown entity or system named, say, G. How will the scientist go about knowing what G is?

The first principle of Science is the Principle of "Do something and see what will happen".

So the scientist does something, which in psychologist's jargon is called "Stimulus". Sociologists might call it "Input". Something happens in Response (X) to the Stimulus (x), or Output corresponding to the Input. By this, the scientist gets a data point, i.e.;

$$(X) = \{G\} (x) \text{ or } x \rightarrow X$$

Of course this one data point is not enough for the scientist to claim "Knowledge" on the entity. The scientists have to try more Inputs and get Outputs. But if the entity (or system) is Linear, it is easier to know what Response would be for any Stimulus. For example, the Linear Entity G would produce a Response 2X for Stimulus 2x, and 3X for 3x, and so on, i.e.;

$$(2X) = \{G\} (2x)$$

$$(3X) = \{G\} (3x)$$

What is more, provided the Entity (System) G is Linear, the scientist can predict what the Response (Output) would be for an arbitrary combination of various kinds of Stimulus, say like

$$(3X + 2Y - Z) = \{G\} (3x + 2y - z).$$

This predictability is an enormous savings in the cost of the research to construct the Knowledge about the Entity (System) G.

Having this sense of Linearity in mind, one looks into texts in Physics, Engineering, Economics, etc. One would find that the majority of Theories are about Linear entities or linear systems. Texts in Psychology, Sociology, Political Science, Anthropology etc. are not explicit in what they mean by "knowledge". But when they do imply "knowledge", they are usually an implicit assumption of Linearity.

Most economic-politico-social policy recommendations from the Power Science are of the Patch-work type which in effect says "Granting that all other things stay constant, do x to get the result X". This is only justifiable on Linearity Assumption. The characteristic of Linear Thinking is that it neglects all complications. It only sees the starting point (the problem as the initial state) and the desired end point, and finds the means to connect the two points. It is like drawing a line between two points without looking at other points around. Perhaps, it is analogous to shooting an arrow at a target. As such, the concentration of attention is necessary and it is not a bad thing to do for itself.

In real systems, however, when one thing is changed, all others change. There would always be the second, third, fourth order effects, like the ripples created by a stone dropped in a lake. Linear Assumption is simple and convenient, but it is a bad "superstition", if it is worshiped as The Best Science. Yet the Insensitivity of the Power Science neglects the higher order effects.

Another trick of the Power Science is that, when the uncertainties in the higher order effects are visible, it goes for "Short Term" projections and makes decisions on that basis. It is hoped that the higher order effects would not manifest in a short time scale taken as the reference frame of the thinking. Unfortunately, the neglected higher order effects do not disappear; they "disappear" only in the short-term thinking. People have to pay for them eventually. A funny thing about this is that we think it

is "scientific". That is the Power Science; it provides an edifying cover not only for the negligence, arrogance, and insensitivity, but for the stupidity. I would think that the Native Science which thinks on a long-term scale would be good "medicine" for the Power Science.

Non-linear entities or systems are that which cannot be treated by Linear Theory. That is the definition. Non-linear entities and systems are nasty, for they defy the simple "predictability" of the kind illustrated above.

Non-linear systems are "Unpredictable", which means there is no possibility of doing the "science" which usually means "predicting power". Of course, we can do a modified sense of "science". In fact, non-linear physics is now getting fashionable, where things like "Catastrophe Phenomena" are studied.

What is so-called "Ecology" in biology and geology is largely confined to Linear cases. Some Biologists and Geologists are aware that Nature is Non-linear and Catastrophic Instability --- such as mass extinction --- is expected. But the prejudice (or rather "superstition") of majority of the scientists demanding "Predictability" for "science" on some emotional ground does not make the study of Non-Linearity in Nature popular.

As to knowledge in social and Humane areas, their implicit Linear "Rhetoric" are yet to be recognized. "Causal Relation" is often nothing more than a Linearized Expression. As a consequence, people do not know they are assuming Linearity. Hence, Linear Thinking is prevalent.

I do not think the "Linguistic Philosophers" are even aware of Non-linearity, except perhaps in Logical Paradoxes. (The "Paradox of Self-Reference" has a "loop structure" and as such it is Non-linear. "Circular Argument" is also Non-linear. They reject it. But interestingly the most "definitions" in sciences are "circular". Newton's Laws of Motion and Darwin's famous statement "Survival of the Fittest" are well known examples. Perhaps, because of these bad cases, philosophers do not like Non-Linearity, But, their dislike prevents them from serious studies of Non-Linearity. This is unfortunate.)

However, the Philosophy of Dialectics is a Non-linear one. [See Thorn cited below] But I doubt Dialecticians themselves such as Marx --- are aware of the Non-linearity.

As to Mathematics of Non-Linearity, see Rene Thom: Structural Stability and Morphogenesis. Benjamin. 1972. (Thom also had an interesting thing to say about Math Education, Science 1972.)

Also, there are several texts on Non-Linear Physics. What is called "Soliton" is an unusually stable wave produced by Non-Linearity. It is to be noted that "Stability" can be a manifestation of Non-linearity. Non-linearity is not always unstable and catastrophic. I suspect almost all biological and social systems (such as human life) is "stable" because of Non-linearity. They "die", however, because of the Non-linearity that maintained them to be stable for a while (quasi-stable).

The escalation of Nuclear Arms race which goes in a "vicious circle" is an example of bad Non-linear Dynamics. On the other hand, the "positive reinforcement" effects in Education etc. are also Non-linear Dynamics.

These examples show that Non-Linearity is important and interesting. But here again, it is too technical to be taught directly in schools. I would appreciate very much if you could suggest to me some ways of bringing "awareness" of Non-Linearity into school science education. Interestingly "Sensitivity" is a highly Non-Linear Phenomenon. I wish some psychologists would write about "Non-Linear Dynamics of Mind". Hegel came close to doing that, but his intellectual snobbism is too much for popular reading. Perhaps, Native Science might have good stories to tell about this.

Oct.18, '87. S. Kounosu Phys. Dept. U. of L.