

## Notes on Building the Scientific Mind 2007 (BtSM 2007)

### Terminology

Some at the meeting objected to the word ‘building’ in the meeting title. Some may have preferred ‘fostering’ or ‘developing’ or ‘enticing’. Some objected to the word ‘mind’ and might have preferred ‘disposition’ or ‘attitude’ – ‘minds’, ‘dispositions’, and ‘attitudes’ were also discussed. Instead of ‘scientific’ some preferred ‘inquiring’ or ‘inquisitive’ and there was discussion about whether and to what extent ‘scientific’ implied empiricism or particular experimental methods or particular kinds of evidence and how scientific inquiry differed from other forms of inquiry. It would be easy to perseverate on semantic nuances and spend all the time on what a difference a word makes. What difference does a word make?

In the beginning there was the word? Really? How odd. What was that word? Well, there was no one around yet to hear or understand ... that would take another week or so ... give or take a few thousand millennia ... so we can only guess. My guess is that the word was ‘oops’. As in, what is this that I have done? As in, what is the sense in all of this? As in, what can it mean? As in, where will it end? This sounds strangely like the beginning of an inquiry process. Inquiry begins in wonder that leads to a question and a desire to explain, predict or otherwise understand a situation or event or set of circumstances that seem unusual or counterintuitive or just plain strange. Inquiry begins with humility – as in, “I do not understand this.” Inquiry proceeds based on a need or desire to understand – as in, “I am unable to proceed without having an explanation of this.”

Perhaps this is the first step in developing a scientific mind – developing a sense of humility. Investigating implies having a question, which implies not knowing or understanding something that one would like to know or understand. We begin from a state of relative ignorance – no ... we begin from a state of admitting our ignorance. Perhaps this very first step is too easily overlooked and not sufficiently appreciated – we are deficient and we must first admit our deficiency in order to investigate. It is this admission of a deficiency – this kind of humility – that distinguishes *asking* a question from *having* a question. To have a question one must not only have a deficiency in knowing or understanding but also be aware of that deficiency and be engaged in activities aimed at remedying that deficiency. Having a question implies being engaged in a search for an answer or explanation. It is easy to ask questions – having questions is altogether different and often difficult and demanding.

Sustaining engagement in an investigation requires an inquiring attitude and persistence. With regard to scientific investigations, it probably also implies an openness to alternative approaches and solutions. A scientific attitude might then be contrasted with a dogmatic attitude. Unfortunately, many scientists become dogmatic from time to time on various issues and occasionally with regard to the validity and value of their own methods and findings. Well, scientists are human, too, subject to all the frailties and shortcomings that we might hope to address in a modern, scientifically-oriented educational system.

## Tensions

There seemed to be a number of tensions within the BtSM community. Some of these tensions might be associated with differences with regard to preferred terminology. Some tensions seemed to be associated with political biases and preferences. Others might better be associated with different perspectives. Regardless, tensions tend all too often to develop into barriers to inquiry. It seems someone ironic to find biases and tensions in this group that is allegedly committed to fostering scientific development. If humility is the point of departure and openness to alternative approaches and possible solutions is a necessary condition for continuing that development, then this group should actively avoid dogma and transform tensions into appreciation for alternative views and explanations. On the other hand, as has been noted, tension and antagonism can contribute to effective learning. Indeed, tension and antagonism can lead to that initial point of departure – I do not know which of these two apparently conflicting and competing explanations is better or preferable – how shall I decide?

Okay. Tensions may be useful and they are probably unavoidable. What tensions did I stumble across? Some of those at the meeting had innovative approaches to teaching and learning science and these were aimed primarily at developing specific problem-solving skills typically associated with doing science or being a scientist. It is clearly possible to commit resources to such endeavors and some will surely lead to noticeable improvements in scientific reasoning. Several such efforts were mentioned at the meeting. However, after the study ended and the resources devoted to those efforts were taken away, the effects did not tend to persist and sustain themselves. The tension in this regard is between the enthusiasm for an innovative approach and the realities associated with the limits of scale and long-term impact. Innovations come and go and there seem to be only very slight and marginal improvements in scientific reasoning in school-based learning and instruction. So it would seem.

A tension between targeted innovations and systemic efforts to reform and transform science education also surfaced on occasion. Let us say for the moment that these two strands can peacefully co-exist, one addressing fine-grained instructional design issues and one aimed at system-wide re-design and reform. With regard to the latter, there is still tension between tradition and habit versus an attempt to remake everything all at once. Changing everything at every level seems quite challenging, and even when mandated by high level policy decisions and supported with resources, such systemic change can fail for many reasoning – one being that it can disenfranchise key people (e.g., teachers) involved in educational reform. The question then occurs – what about and within the system can we reasonably expect to change that will have recognizable and sustainable impact? I do not have an answer to that question, and I admit to not *having* that question – I am only *asking* it with the hope that others will have that question and become engaged in seeking answers.

A different kind of tension involves two different kinds of goals: (a) appreciating science, and (b) doing science. Is our goal to develop lessons and courses and curricula in our

schools that will help students develop a deep and abiding appreciating for science. We have such instruction for art and music but none for science. Are there no science appreciation courses? I thought several said there was beauty in science ... but there are no courses aimed at learning how to appreciate that beauty insofar as I know. Is that not odd? It is an entirely different think to teach someone to appreciate X than it is to teach someone how to do X. We must be clear about this difference and determine which we want to do, when and for whom. I do not think we resolved this at this meeting.

A related tension exists between these goals: (a) valuing science, (b) learning about science. This is similar to the previous distinction and arose in many different contexts. What occurs in schools now might be characterized as learning about science – albeit in the fragmented way that several described. There appears to be too little emphasis and elaboration provided for what scientific values such as skepticism (in the sense of not knowing something, admitting that one does not know, and being engaged in an investigation – the word ‘skeptic’ is derived from the Greek for ‘search’ – skeptic is a searcher ... a seeker ... an inquirer. We have misunderstood and devalued skepticism. We ought to correct this in schooling somewhere ... in my less than humble opinion.

Science as a way of living ... is that our aim ... to help students develop an inquiring and inquisitive and investigative spirit that pervades all aspects of their lives? Does science inform our lives in that way? Intermittently, perhaps ... as in, “I am scientific on occasion and not in a very predictable manner.” Really. Half the people can be mediocre scientists part of the time. All the people can be poor scientists all of the time. But not all of the people can be thoroughly scientific all of the time. Bob Dylan did not say that. I did.

Other tensions mentioned included formal versus informal learning - learning from significant events versus learning in classrooms. On other occasions I have heard some advocate for the creation of significant events in the classroom – I know of no evidence showing how this can be done with any consistency or meaningfully. Informal learning is typically non-intentional, unplanned and accidental – haphazard but still memorable and effective when it occurs. Would it not be confused to try to plan such unplanned events as Tolstoy describes in *My Confession* when he chanced upon a public execution in Paris?

### **Perspectives** (I lost momentum at this point – call this the banquet effect)

Atomistic vs. holistic

Reductionist vs. systemic

Static vs. dynamic

Analytic/empirical vs. synthetic/hermeneutic