Science Education Buffeted by the Gales of Fundamentalism and Relativism (SLCS 183)

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I want to remind us that culture is very real, it is very important, and can act or operate in both subtle and obvious way.

The purpose today is to agree with the opinion that all science, including science education is culturally situated. And that that science educators need to pay attention to cultural issues and do our best to ensure that scientifically inconsequential cultural baggage does not bog down our students desire to learn and accomplishment in the sciences.

We live in a world, however, where there are voices in science community -- and by science community I refer to scientists, science educators, policy makers and commentators -- who wish to hijack science for their own ideological perspectives. Hence the title of my talk, science education traverses a sea buffeted by gale force winds of *isms*: fundamentalism and relativism.

Science Education Traverses
A Sea Buffeted By Gale Force Winds Of *Isms*:
Fundamentalism and Relativism.

Just make sure that I'm speaking clearly, by fundamentalism, I am referring to religious fundamentalism, but as I will explain religious fundamentalists include the likes of Richard Dawkins and Dennis Dennett, who are of course avowed atheists. By relativists, I have in mind those who reject any form of universality in science.

The theme of this paper is one I have defended for the past 20 years: epistemological pluralism.

Epistemological Pluralism

I reject positions of scientific and epistemological relativism. Not all thoughts are equal. Not all ways of thinking are parallel. But life is a complicated affair and the skillful navigation of life requires a diverse repertoire of thought and reason. And what is essential for a suburbanite American to understand about Nature will not be satisfactory for the local indigenous fisherman living in a very different world. Thus, what I value is the best thinking for a given situation, the ability to wisely discriminate amongst competing claims, and the wisdom to change one’s thinking when situations change. This is called *epistemological pluralism*.

I believe that it is important to define science with sufficient clarity so as to maintain a coherent boundary for the practical purposes of school science curriculum development. My colleague Cathy Loving at Texas A&M University have written about this and use the term, Standard Account of science. The Standard Account creates a boundary excluding most forms of indigenous knowledge, if not all, just as it excludes art, history, economics, religion, and many other domains of knowledge. Being exclusive, however, does not confer science with any privilege vis-à-vis other domains of knowledge.

Being exclusive does NOT confer science
with any privilege vis-à-vis other domains of knowledge.

Science is properly privileged only within its own domain for that is where its strength lies. When indigenous knowledge is devalued at school it is not because of the exclusive nature of the Standard Account. It is because someone is involved in the scientistic practice of extending scientific privilege from its proper domain in science and technology into other domains. The solution is to resist this scientistic practice by emphasizing throughout schooling the concept of epistemological pluralism.

But epistemological pluralism as a pragmatist, centrist perspective on science and science education suffers the affronts of extremists—those who have no interest in sharing the playing field, only to dominate it. These extremists are well known to us.

Scientific Fundamentalists
&
Multicultural Relativists

They are, on the one hand, scientific fundamentalists who oppose all cultural perspectives save their own scientistic perspective. And on the other, they are the multicultural relativists who oppose scientific universalism. It falls to the pragmatists to fight off both camps if science education is to be both successful and humane.

For the balance of this talk, I will first discuss scientific fundamentalism, then multicultural relativism, followed by a few concluding remarks on policy. I will then end with a short story that I hope you will find both amusing and instructional.

Scientific Fundamentalism

People usually think of religion when the word “fundamentalism” is heard and properly so. What we often do not realize is that there are those who elevate science to the level of religion. There are those who believe that the great power of science has freed humanity from any need of a transcendent power or authority, in a word, any need of God. Science replaces God. They will tell us that:

- The weather is not the will of God. Weather patterns are explained very will by the interaction of the earth’s many physical features and the sun.

- If crops are not growing well, we need not pray, but we do need to genetically breed better crops and make better use of fertilizers.
- If you get sick, don't bother to pray, but do call a modern scientifically trained physician.

And for heaven's sake no human should consider himself or herself of any superior importance in the animal kingdom, for Francis Crick assures us that:

> your joys and your sorrows, your memories and your ambitions, your sense of personal identity and free will, are in fact no more than the behavior of a vast assembly of nerve cells and their associated molecules (p. 3)

Indeed, it is only human folly to think that earthly life has any purpose at all save for what we ourselves make, for in science

> there is no mention of, or mechanism for achieving, any long-term metaphysical or teological (sp) goals of form, complexity, or intelligence… This is the truth science has revealed…. (Zeigler, 2008)

For science is

> the only discipline in which one could find real objective truth, the only view which could inform one as to the true nature of reality. (Zeigler, 2008).

Well, these people are free to believe what they want. The problem is that they claim the mantle of science for their scientistic religion and in so doing they disparage all other religion and cultural practices that do not confirm to their scientistic norms. The mischief that this leads to was brilliantly portrayed in the book, "Machines as the measure of man: Science, technology, and ideologies of western dominance," by Michael Adas.

Machines as the Measure of Man:
Science, Technology, and Ideologies
of Western Dominance

Although speaking of 18th and 19th century Europe, his observations remain apt with regard to 21st century scientific fundamentalists:

> Perceptions of the material superiority of their own cultures, particularly as manifested in scientific thought and technological innovation, shaped their attitudes toward and interaction with peoples they encountered overseas… perceptions of the material superiority of their own cultures, particularly as manifested in scientific thought and technological innovation, shaped their attitudes toward and interaction with peoples they encountered overseas…. In the late eighteenth and nineteenth centuries, most European thinkers concluded that the unprecedented control over nature made possible by Western science and technology proved that European modes of thought and social organization

> corresponded much more closely to the underlying realities of the universe than did those of any other people or society, past or present. (Adas, 1989, p. 7)

Indeed, in 1962, the flagship journal of American science, *Science Magazine*, ran an article titled “Measuring the growth of science,” in which the author speculated about all the nations of the earth moving toward a single science-based world culture.

Fortunately, this self-laudatory, ethnocentric thinking as largely disappeared from the pages of Science magazine, having foundered on its own failure of logic. A moment ago I quoted a scientist saying that in science:

> there is no mention of, or mechanism for achieving, any long-term metaphysical or teleological goals of form, complexity, or intelligence… This is the truth science has revealed…. (Zeigler, 2008).

The first failure of logic lies in the observation that certain things cannot be found in science followed by the conclusion that these certain things thus do not exist. This is on a par with concluding that television signals do not exist since they are not “revealed” by my radio.

> On my radio, there is no television. This is the truth radio has revealed.

The second failure of logic is the implicit assumption that because one explanation is available (the scientific one) no other explanation or explanations are warranted. Presumably these true believers never read Aristotle’s work on causality

> Material Cause
> Formal Cause
> Efficient Cause
> Final Cause (*Physics*, II.3)

Where only the Material Cause conforms to our modern understanding of scientific explanation. The point is that there are people who already believe certain things about the world (in this case that there are only material causes) and they then use science to support those beliefs. Richard Dawkins admitted as much when he wrote:

> An atheist before Darwin could have said, following Hume: "I have no explanation for complex biological design. All I know is that God isn't a good explanation, so we must wait and hope that somebody comes up with a better one." I can't help feeling that such a position, though logically sound, would have left one feeling pretty unsatisfied, and that although atheism might have been logically tenable before Darwin, Darwin made it possible to be an intellectually fulfilled atheist.

As I have already noted, people are free to believe as they wish, but much of the controversy over issues such as evolution, and the science of origins, is generated by a

few highly public proponents of scientific fundamentalism masquerading their religion as science. And of course their implicit imperialistic attitudes degrade all matters of culture. They would equally say that aboriginal fishing methods, for example, may be quaint and of some cultural interest, but clearly of no epistemological value in comparison to modern science.

Though often publicly visible and very bothersome, these scientific fundamentalists are relatively few in number. The turn to culture that begin in the 1960s has made it virtually impossible to ignore the importance of culture, including the notion of science as a cultural phenomenon—impossible, that is, except for the scientistic true believer.

The Turn to Culture

I don't think I need to rehearse the events of the social study of science these last 40 years. Suffice it to say that eventually, the searing eye of scientific empiricism got focused back on science itself. Beginning with Thomas Kuhn's *The Structure of Scientific Knowledge*, the social, cultural, economic, political, and religious interactions and mutual influences on the creation of scientific knowledge have come more and more to light.

Worldview
Feminist
Indigenous epistemology
Religion
Economic

I am happy to have made small contributions through my research and theorizing and as the founding section editor for Culture and Comparative Studies for the journal *Science Education*. One must also recognize the important contributions by Nancy Brickhouse, Glen Aikenhead, Masakata Ogawa, Meshach Oguniyi, and Olugbemiro Jegede. There is also the very informative *Indigenous Science Network Bulletin* operated out of Australia, and there is the new journal: Cultural Studies in Science Education. I continue to applaud and participate in the cultural study of science. My work is all posted at: Scientific Literacy and Cultural Studies Project (SLCSP). The work that is being done to raise awareness of, and save indigenous knowledge, and to bring that knowledge into the educational system is laudatory. One easily thinks of the work done amongst aboriginal peoples in North America, Hawai'i, Papua New Guinea, and South Africa to name only a few places.

I am however concerned over what I perceive as Newtons's 3rd Law acting in the social realm: For every action there is an equal and opposite reaction. The "action" is that both in the past and in the present, members of the science community over reach. They claim too much in the name of science. And to this "action" we now have the "equal and opposite reaction" of cultural relativism.

Newton's 3rd Law

(For every action there is an equal and opposite reaction)

Scientific Fundamentalism (Action) ⟷ Cultural Relativism (Reaction)

My pragmatism as well as my critical realist epistemology leads me to equal distain for both, but I am getting ahead of myself.

For my purposes today and with regard to the turn to culture, I focus on four seminal observations from a vast body of literature in the social and cultural study of science and science education.

Scientific knowledge changes
Social/cultural factors influence science

Scientific knowledge can be disruptive of culture
Scientific knowledge has been used to subjugate and to oppress.

The first two points are epistemological in nature, while the second two are not. The second two are sociological and political in nature. It is the penchant for ignoring this critical distinction that leads to cultural relativism. I want to now focus briefly on cultural relativism in science education before returning to this important distinction and the need for it to be manifested in science education.

Cultural Relativism in Science Education

I have no objection to the notion of "Western" science in that the modern practice of science is of western origins. For cultural, political, economic, and religious reasons along with reasons yet to be uncovered, the modern practice of science originated and developed in Western societies. It has since spread such that there are practicing scientists in all nations of the globe, and as noted, this spread has been disruptive at times and scientific knowledge sometimes comes into conflict with local knowledge. Sometimes the conflicts and disruptions are caused by "western cultural baggage" that often gets communicated with science and sometimes it is science *qua* science: science the thing in itself. For example, there is a cultural belief primarily in North America that the earth is no more than 14,000 years old. Well there is no cultural repackaging of science that will avoid a culture/science conflict. Either the science is wrong or the cultural belief is wrong about the age of the Earth. Or if one prefers: either the cultural belief of science is wrong or the cultural belief of Young Earth Creationism is wrong.

I believe that the original response by the science education community to the disruptive spread of scientific knowledge was to attack the "baggage problem" and the scientistic proclivities of some scientists and all too many policy makers. That remains in my opinion the best course of action, which is why I continue to argue the case for epistemological pluralism.

I am deeply concerned however that others now seek to defend against scientism by rejecting the universal epistemic claims of scientific knowledge, that is, science qua science, that is, science as something in and of itself. For example, in a recent issue of the *Cultural Studies of Science Education*, one researcher writes:

> Neo-colonialism is the imposition of the invaders' worldview on the invaded culture, perpetrated by those who have a disregard for the people of the invaded culture…. It is assumed that the invaded culture will be transformed (''developed'' from the neo-colonial perspective) to resemble the economic and technological cultures of the invaders, that is, the Eurocentric culture that dominates the world. (Ryan, 2008)

When this author refers to an assumption that the "invaded culture will be transformed" or "developed," one is immediately reminded to the economic growth theories and theories regarding the expansion of science that dominated the 1960s, the view that we are marching toward a single world-culture dominated by science. These indeed were Eurocentric and imperialist notions, and the author of the piece in the *Cultural Studies of Science Education* correctly goes on to indict the appeal to universal science. The problem is that this author along with many others makes no distinction between science understood in the 1960s as completely independent of culture and today's understanding that all knowledge is culturally situated. Put another way, the notion of cultural baggage was only emerging in the 1960s but today we have the capacity to identify and sort cultural baggage.

Rather, however, than putting this distinction to good effect, the turn to culture becomes the turn to relativism. We are told that of the claim to epistemological universality is a myth. Science is culturally western and therefore incapable of universality.

What can this possibly mean? It is easy to see how the practice of science is influenced by culture. The current issue of embryonic stem cell research is a case in point. The US Government has severely limited tax-based research funds for embryonic stem cell research primarily due to Christian opposition based on the sanctity of life. Such research has continued unimpeded in Asia where embryonic stem cell research has been justified on the basis of Buddhist and Hindu beliefs in the recycling of life via reincarnation. Other examples of cultural influence in science could be cited but these only indicate that the practice of science is never completely objective. It is never completely culturally autonomous.

And scientific traditionalists such as me argue that the processes of science nevertheless work through and with culture to arrive at the best epistemic explanations for natural phenomenon. Thus in my own work, I have always maintained a distinction between the epistemological and the social, cultural and political. But this view is insufficient for the committed cultural relativist. One such relativist took me to task on this:

> to say that "it makes sense that an isolated scientific concept (e.g., photosynthesis) is *a*cultural close quote carries many cultural assumptions, including the

> assumption that it is sensible to conceptually isolate and name a hypothesis about the processes that may relate foliage to energy conversions. I would have no disagreement with Cobern if he had written that, *from a Western cultural standpoint*, it "it makes sense that an isolated scientific concept (e.g., photosynthesis)" *appears to be* "*a*cultural." Gough

Which leaves me scratching my head as to whether these people think that nature really does have no role in the nature of scientific knowledge? The answer seems to be no, it does not. Hilary Lawson makes the point using Galileo as the example:

> "None of the evidence, which Galileo offered carried conviction, none of it actually proved then that the Earth was moving round the sun. We believe Galileo's experiments, because we believe that the earth moves round the sun."

To which we might ask, if there was no reason grounded in evidence to take Galileo seriously, why do we now see the universe as he did? Because,

> "By the end of the 17th century, telescopic astronomy had become a very useful resource for the new maritime and commercial powers of northern Europe. Galileo triumphed not because he was right but because his theories were extremely useful. And because they were useful, his observations came to be believed to be true."

There you have it. Scientific debates are not decided by simply looking at reality, by looking at the evidence. The theories and laws of science, which we now take for granted, are not about truth but merely that which we have come to believe to be true given the usefulness of the ideas. The equation seems to be:

An Idea is Useful Therefore it is Believed Therefore it is True

And if this *is* the equation for truth, and given that “useful” can mean most anything to anybody, and will certainly be highly influenced by the most vested interests, then there really is every reason think that all epistemologies regarding nature are on a par given that each has been sanctioned “as useful” by its respective community or respective power-broker.

As noted, the ground for this opinion begins with two key observations that scientific knowledge does changes, sometimes in revolutionary ways, and that social and cultural factors play an important role in the creation of scientific knowledge.

I argue, however, that we should not be carried away by the reality scientific change, being fully aware that all knowledge is fallible and hence it is to be expected that scientific knowledge changes, sometimes in revolutionary ways and sometimes, perhaps even all the time, bearing the influence of cultural factors.

Scientific knowledge is also remarkably stable, supported by multiple strands of evidence and reason, and is applicable no matter where we are on earth and no matter who it is that wishes to employ it.

Speed of light
Radiation decay
Photosynthesis
Protein synthesis
DNA basis for both inheritance & development
The Planetary system

I argue that such scientific descriptions encapsulate or capture truth about the physical world that is not undermined, let along thrown over, by incompleteness and fallibility. What possible reason can there be for denying the universal reality for all inhabitants of earth, regardless of culture, that the earth orbits the sun and not the other way round?

I thus argue that scientific knowledge is *a*cultural in that scientific knowledge describes physical phenomenon or accounts for physical phenomenon that physically occur and are physically the same regardless of human culture. That is, that scientific knowledge is not a function of ethnicity: whether I am an American, Taiwanese, Korean, Australian aboriginal, Vietnamese, North American aboriginal, Nigerian, Russian, Kenyan, Pakistani, or Afghani, whether I am a man or I am a woman, the speed of light is the speed of light and photosynthesis is photosynthesis and the earth orbits the sun and not the other way around.

None of this suggests that the practice of science is completely unproblematic. We should never forget that there is no practice of science outside of the existence of scientists and those who make use of scientific knowledge. Given the nature of humanity of course, the enterprise of science is going to have its share of problems. I tend to share St. Augustine's view on the sinful nature of humanity. This simply means that if there is a possibility for men and women to make mistakes or to intentionally do evil, mistakes will be made and some men and women will do evil. Membership in the community of science is no guarantee of infallibility or moral rectitude or wisdom.

So yes, people in the West have used the enterprise of science for imperialistic purposes and indeed for evil purposes. We should also not be mistaken that such propensities are the sole province of Western humanity. Aboriginal peoples have destroyed their environments such as on Easter Island, they have hunted species to extinction, such as in New Zealand, and they have nearly made themselves extinct through murderous, internecine raids such as the Auca of South America.

But I digress.

It is undoubtedly true that the modern enterprise of science is not everywhere valued and esteemed at the same level or in the same ways or for the same reasons. It is beyond question that cultural background does influence one's thinking about science. One can

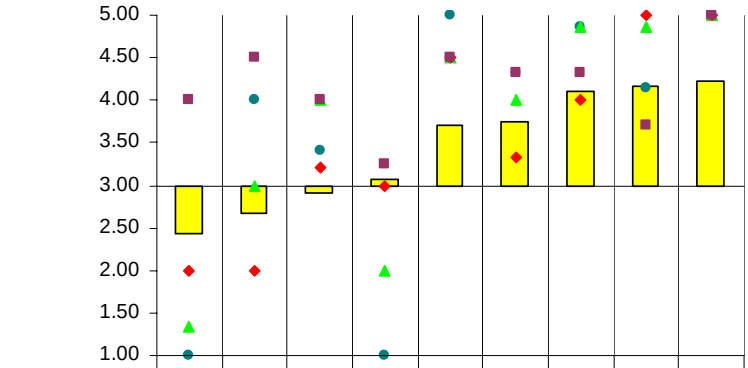
go even further and note that not even scientists have a uniform, homogenous view on the value and purposes for science.

For that last several years I have been collecting data on the ways in which pre-service elementary teachers value science. None of the students are science majors. We use a model composed of nine categories and we are asking about the valuation of science vis-à-vis each of the categories. The categories are:

- **Epistemology**
- **Science and the Economy**
- **Science and the Environment**
- **Public Policy and Science**
- **Science and Public Health**
- **Science and Religion**
- **Science and Aesthetics**
- **Science, Race and Gender**
- **Science for All**

On the chart I show the teacher means for each category and one can see a range of commitment. Teachers generally think that all students should study some science and that science is very important with regard to public health, the economy, and the environment. They however do not think that only science knowledge is important (epistemology); they believe that scientific research needs to be regulated; and they reject anti-religious views based on science.

Category Means for Four Scientists vis-à-vis Elementary School Student Teachers



	POLY	RELIG	EPIST	R & G	BEAUT	ENVIR	ECON	For_All	HEAL
Student Means	2.43	2.66	2.90	3.07	3.71	3.75	4.10	4.17	4.22
Scientist 1	1.00	4.00	3.40	1.00	5.00	4.33	4.86	4.14	5.00
Scientist 2	1.33	3.00	4.00	2.00	4.50	4.00	4.86	4.86	5.00
Scientist 3	2.00	2.00	3.20	3.00	4.50	3.33	4.00	5.00	5.00
Scientist 4	4.00	4.50	4.00	3.25	4.50	4.33	4.33	3.71	5.00

Now here is the interesting point. Look at the data from four first-rate research scientists who agreed to provide their views. Their data points are quite scattered. This is my point, that even the best of scientists have substantial differences concerning the value and purposes of science. For the most part, scientists are not scientistic.

It makes sense then that science can be taught within cultural contexts, showing great cultural variation, without concluding that science is culturally determined. Indeed, accepting the epistemological universality of scientific knowledge is what will vouchsafe any culture's indigenous knowledge of the physical world. We all share the "common ground" of Earth, our planet, which is the final arbiter of scientific ideas. Therefore, any proposed knowledge that provides insight on our shared physical world can gain a hearing in the community of science, regardless of its origins, regardless of local influences, regardless of its cultural origination.

Rules for Curriculum and Instruction

RULE 1: Teach science, not scientism. No one embraces scientism by acknowledging the universality of scientific knowledge. Scientism is science high-jacked for self-righteous and self-aggrandizing purposes. It is a true problem and no one should take this problem lightly.

RULE 2: Teach for sound understanding not belief. Even when science instruction is culturally contextualized, there will always be the potential for cultural conflict. Given human fallibility and limitations, no system of knowledge is perfect, modern science or indigenous knowledge. Hence, we want students to understand scientific reasoning, evidences and conclusions. If they choose not to disbelieve some aspects of science, so be it. People do not find all evidence equally compelling. People are not always as convinced, as are scientists by the same evidence. People often have other evidences that are more compelling to them, or authorities that are more trusted. Ignoring these realities is simply counterproductive because it leads students to feel that they are being indoctrinated rather than taught. To disbelieve, moreover, does not bar understanding. Indeed, students are much more open to learning when they are confident that the teacher is not trying to "convert" them.

RULE 3: Teach the *evidence*. This rule is simply good science teaching but too often the science curriculum is what Joseph Schwab called a "rhetoric of conclusions." The conclusions are needed (e.g., the outlines of the general theory of evolution); but without some introduction to the evidence that scientists adduce in support of scientific theories, student understanding of science will be weak. Worse, some students will conclude that science is merely ideological. If we want skeptical students to develop confidence in scientific knowledge, Rule 2 requires Rule 3.

RULE 4: Give students time to explore their own ideas. From metaphysical theories to epistemological theories of coherence to cognitive theories of conceptual change to democracy and the free exercise of ideas, it makes no sense to ignore ideas that students bring from their homes to the classroom that the students deem relevant regardless of

what their science teachers think. This is especially true as one moves farther and farther away from Western cultures to cultures where there are rich repositories of indigenous knowledge of nature. Science teachers need to acknowledge that this diversity of thought is very likely to exist and should encourage students to explore the knowledge within their own communities. To do so creates an hospitable environment that will open possibilities for learning rather than closing them off. It encourages students to understand science without feeling compelled to reject their cultural heritage.

To my way of thinking, these rules represent a humane approach to science education that rejects scientism without slipping into epistemological relativism. This is the “Don’t throw the baby out with the bath water” approach to multicultural science education.

Conclusion

I now will bring my talk to a close with a story. It is called The Barometer Story. Some of you may know of it. I will give a shortened version of the story so if you want the full story please let ask me for it. This story comes from a physicist by the name of Alexander Calandra who published this story in the late 1960s. He claims that the story is true.

Some time ago I received a call from a colleague who asked if I would be the referee on the grading of an examination question. He was about to give a student a zero for his answer to a physics question, while the student claimed he should receive a perfect score and would if the system were not set up against the student: The instructor and the student agreed to submit this to an impartial arbiter, and I was selected.

I went to my colleague's office and read the examination question: "Show how it is possible to determine the height of a tall building with the aid of a barometer." The student had answered: "Take a barometer to the top of the building, attach a long rope to it, lower the barometer to the street and then bring it up, measuring the length of the rope. The length of the rope is the height of the building."

I pointed out that the student really had a strong case for full credit since he had answered the question completely and correctly… but I suggested that the student have another try at answering the question. I was not surprised that my colleague agreed, but I was surprised that the student also agreed.

I gave the student six minutes to answer the question with the warning that the answer should show some knowledge of physics. The student dashed off his answer which read:

> "Take the barometer to the top of the building and lean over the edge of the roof. Drop that barometer, timing its fall with a stopwatch. Then using the formula $S = ½at^2$, calculate the height of the building."

At this point I asked my colleague if he would give up. He conceded, and I gave the student almost full credit.

I recalled that the student had said he had many other answers to the problem, so I asked him what they were.

> "Oh yes," said the student. "There are a great many ways of getting the height of a tall building with a barometer. For example, you could take the barometer out on a sunny day and measure the height of the barometer and the length of its shadow, and the length of the shadow of the building and by the use of a simple proportion, determine the height of the building."
>
> Or,
>
> "There is a very basic measurement method… In this method you take the barometer and begin to walk up the stairs. As you climb the stairs, you mark off the length of the barometer along the wall. You then count the number of marks, and this will give you the height of the building in barometer units. A very direct method."
>
> "Of course, if you want a more sophisticated method, you can tie the barometer to the end of a string, swing it as a pendulum, and determine the value of 'g' at the street level and at the top of the building. From the difference of the two values of 'g' the height of the building can be calculated."

Finally, he concluded, there are many other ways of solving the problem. "Probably the best," he said, "is to take the barometer to the basement and knock on the superintendent's door. When the superintendent answers, you speak to him as follows: "Mr. Superintendent, here I have a fine barometer. If you tell me the height of this building, I will give you this barometer."

The story ends with Calandra asking the student why he didn't simply answer the problem they way the professor wanted it answered since he obviously knew how to solve this problem.

The student responded that as an academic lark, he decided to revive scholasticism. Well this student was actually making a very insightful point. Scholasticism was the European Medieval method of analysis that sought to find as many ways possible for solving a problem and then synthesizing unity from those disparate methods. In my view, that is an excellent approach to placing science within culture and culture within science. Multiple points of view synthesizing a whole, or in a phrase: Epistemological Pluralism --- but relativism? Never!

Thank you very much.