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American Research Institute for Policy Development
42 Monticello Street, New York, NY 12701, USA.
Phone: 1.347.757.4901 Website: www.aripd.org/jehd

# The Philosophical Eclecticism of Science and its Impact on Science-Education

**Laila N. Boisselle**[1]

**Abstract**

The essay marries Geertz' (1973) conception of two sciences with Snow's (1959) proposition of two cultures to create a theoretical framework that aligns the processes of science with interpretivist, qualitative practices, and the products of science more so with positivist, quantitative, experimental practices. This theoretical framework is then used to investigate and account for the seeming dichotomy of society's apparent fascination with scientific-products against a demonstrated drop in the pursuit of school science and scientific careers (i.e. the processes of learning and doing science). I propose that this dichotomy might be due to a misunderstanding in the general population of the character or nature of science and might be addressed by reforms to the curriculum of science. I suggest that such a reformed science-education curriculum should aim at a scientific-literacy capable of appreciating the character of science as both interpretive and experimental. It should also aim to foster an understanding of both the standard account of science as well as science(s) indigenous to the pupils under instruction.

**Keywords:** Nature of science; indigenous science; science education; scientific literacy; public opinions of science; disinterest in science education.

## Section 1: Introduction – A Philosophical Eclecticism?

*"Eclecticism is self-defeating not because there is only one direction in which it is useful to move, but because there are so many: it is necessary to choose" (Geertz, 1973, p. 5).*

## Aim of the Paper

I suggest that a reformed science-education may help to align society's disinterest in science more closely with its apparent fascination with scientific-products.

[1] The University of the West Indies, St. Augustine, Trinidad and Tobago.

Within an aim of scientific-literacy, I recommend that the curriculum for such a science-education represent the character of science as both interpretive and experimental, and foster an understanding of both the standard account of science as well as science(s) indigenous to the pupils being instructed.

## The Issue

A growing disinterest in scientific-study and scientific-careers is being blamed on the way in which science is taught (Burnsed, 2011; Gay, 2002; Mitchell & Hoff, 2006; Wolff-Michael & Lee, 2004). In stark contrast to this expanding disinterest, science's epistemological hardiness and reliability, as well as its immense contribution to humankind's development, allows it to still enjoy a hegemonic status (Carter, 2008, p. 175). Certainly, societies are increasingly charmed with products of science, many of which have become cultural staples.

## The Theoretical Framework of this Paper

In attempting to account for this contradiction of a world seemingly disenchanted with science education and careers yet enamoured by its products, I have invoked Geertz' proposition of two sciences: "...an experimental science in search of law...[and] an interpretive one in search of meaning" (1973, p. 5). This was Geertz' explanation to describe anthropology's shift from the dominant use of positivist methodologies such as behaviourism, towards relativist methodologies which suggested that persons create meaning from their enmeshment within symbolic webs of significance often inherited through history (Geertz, 1973, p. 5). Geertz' two sciences then can be succinctly represented as a positivist-experimental vs a relativist-interpretivist position.

Earlier, in 1959, Snow had proposed two cultures which Hess later (1993 as cited in Franklin, 1995, p. 165) aligned to the character of Geertz' two sciences. Snow's two cultures are indicated as "literary intellectuals at one pole–at the other scientists, and as the most representative, the physical scientists" (Snow, p. 169).

For sure, physical scientists have long been considered positivists whilst literary intellectuals are often considered as relativists (Berg, 2004, pp. 2&7; Tomal, 2010, p. 3).

Interestingly, Geertz has described this dichotomy of positivist-relativist positions in terms of two “sciences”: a term normally associated with positivist methodologies. In contrast, Snow has done so as two “cultures”: a term generally associated with interpretivist viewpoints thought discordant to positivist thinking. The argument itself then, is also framed in positivist-interpretivist terms.

I am suggesting that this positivist-relativist dichotomy is embedded too within scientific-philosophy and lies at the root of the inarticulation between society’s high interest in scientific-product as compared to its low interest in scientific-study and careers. Whether defined in terms of cultures or sciences, Snively and Corsiglia (2001) support that this positivist-relativist dichotomy is really about “the nature of reality and knowledge, [and] definitions of science” (p.7).

Positivist philosophy suggests a fixed, and universal reality or world, measureable through the collection of empirical data, (often in quantitative forms). Such data can be used to generate theories, or “explanations as regularities” (Jones, 2011, p. 202), about the way the world works. These theories can be later applied to predict and control systems towards the development of specific products, technologies, or outcomes. Processes are not important here since “to be able to ‘drive’ the system does not require understanding how the ‘engine’ works...[it is facilitated by] an instrumentalist rationality, whereby scientific thinking itself has become an ideology; the ends justifying the means” (p. 202).

Relativism has long been thought to stand opposite to positivism, and uses qualitative inquiry to interpret and represent the meanings that individuals construct as they interact with the world about them (Merriam, 2002, pp. 3-4). These meanings are determined as “inhabitants make sense of their surroundings through symbols, rituals, social structures, social roles and so forth” (Berg, 2004, p. 7).

This essay aligns an ‘experimental-science’ more closely to a positivist view or the utilization of science as ***theories, products or technologies***. Note that technology in modern spaces is often thought to be digital. Within this essay though, technology refers to the historic meaning in which science is applied to make some useful product, which may not necessarily be digital.

An ‘interpretive-science’ I align closely to qualitative methodologies and the ***process*** by which scientific experimentation occurs, how science makes meaning as it comes to know, and how it acculturates others into those methods.

Notably, the essay draws harsh lines between interpretivist and experimental science really only to facilitate the ease of the discussion. It is deeply appreciated that these two sciences are entwined along a continuum and may be occurring simultaneously at many times in the scientific-endeavour.

## Summarising the Purposes of this Paper

The seeming contradiction between society’s disinterest in science-education as compared to its high interest in the products of science may simply therefore be a manifestation of the philosophical condition of science. Certainly, little headway has been made in settling the relativist-positivist divide existing at science’s philosophical-core. Franklin (1995) suggests that generally, “no one has provided the social engineering to bridge the [relativist-positivist] gap more than sporadically in the interim, confirming the tenacity of an opposition” (p.166). In the absence of a truce, the dichotomy of interpretivism and positivism appear to have been separately, and possibly unwittingly, embraced within different spheres of the scientific-enterprise. For instance, even though the research process of science may be prevalently interpretive, science-as-experiment might dominate the societal-mind because of society’s avid use of technological products.

The outcome of this battle seems to result in an array of numerous sciences defined at various points along the philosophical continuum between the positivist-interpretivist poles: with scientists in each camp defending that point, and the lay-people with scientific-literacies insufficient to make sense of the battle caught unwittingly in-between. On such a playing field, I disagree with the assertion of Geertz (1973, p.5) quoted at the start of this section: in this situation at least, eclecticism might *not* be self-defeating. An eclecticism where the personalities of interpretive-science and experimental-science openly co-exist, their individual contributions to the nature of science and the scientific-endeavour recognised, accepted and harnessed, might help to begin to resolve these contradictions.

A science-pedagogy recognising the character of science as both experimental and interpretivist might help to produce a society with stronger scientific-literacy, more aware of the capabilities of science, more realistic in their demands of science, more demanding in the levels of accountability to which science is held, and generally demonstrating more interest in science and its endeavours. Moreover, an interpretivist-science resists an exclusionary, standard account of science by welcoming the cultural ways of doing science and coming-to-know, to which students under tutelage are enculturated in their communal lives.

## Section 2: Eclecticism is the Middle of the Road

### 2.1 Attempting to define what the practitioners of science do: The nature of science

*"To settle whether science is interpretivist or experimental it may be useful to consider operationalism as a methodological dogma...if you want to understand what a science is, you should look in the first instance not at its theories or its findings, and certainly not at what its apologists say about it; you should look at what the practitioners of it do" (Geertz, 1973, p.5).*

To facilitate the discussion it is necessary for the reader to note my demarcations. Within the scholarly literature "the Nature of Science" can commonly refer to the peculiar characteristics or attributes of science themselves, *as well as* to studies *about* those characteristics, and is generally indicated simply as "the NOS". For the sake of clarity, within this essay I do not personally utilize the term "the NOS", and make clear distinctions when I am discussing ***the characteristics/nature*** of science as opposed to ***studies about*** the nature of science.

The literature reveals *studies about* the nature of science as an expansive and argumentative field, which tries to substantiate why science is viewed in the myriad ways that it is. This substantiation embraces ontological and epistemological concerns – what does science consider to be real? Through what methodologies does science come to learn about, and measure this reality? And finally, what type of knowledge is considered to be viable scientific-knowledge? *Studies about* the nature of science are considered as the "social-studies of science" and look historically at the philosophy of science, at how science has been developing scientific-knowledge, and at cognitive research about how people develop meaning or come-to-know (Mc Comas, 1998, p. 4). *Studies about* the nature of science are hence concerned with science as a way of knowing, as well as the beliefs and assumptions that guide this epistemological process (Lederman, 1992, p. 331).

*Studies about* the nature of science then are more concerned with the methodologies than the methods of science – that is, the undergirding ontological and epistemological concerns (Abd-El-Khalick, Bell, & Lederman, 1998, p. 418) regarding the methods by which science collects, analyses, and draws conclusions from data about the natural world (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002, p. 499).

As outcomes, *studies about* the nature of science attempt to provide a rich definition of science and how it works; to describe the social functions within scientists as a sub-group as they derive scientific knowledge; and to consider societal management and response to scientific knowledge-creation within its midst (Clough, 2006, p. 463; McComas, 1998, p. 4).

Whilst there is sufficient clarity on the function of *studies about* the nature of science, there is a weak consensus regarding the specific *characteristics* of science (Clough, 2006, p. 463; W. W. Cobern, 2000, p. 219; Lederman, et al., 2002, p. 498; Lederman & Lederman, 2004, p. 37).

Cobern (2000) proposes that the contention about what exactly is *the nature or characteristics* of science has arisen because of an increasing philosophical shift within the *studies about* the nature of science. He explains that earlier on, the characteristics of science were determined from a position within the boundaries of the philosophy of science – long considered foundationed by the positivist belief of a world independent of the observer, waiting to be discovered and defined. In recent times Cobern goes on to suggest, the *studies about* the nature of science are being positioned outside of the walls of science-philosophy and are being filtered through models historically considered non-scientific. These models emanate from the sociology of science and literary criticism – domains strongly informed by the social-construction of knowledge, and in deconstructivist approaches (Cobern, p.220), and hence strongly supportive of interpretivism.

This shift in the philosophical consideration of science from within positivist to interpretivist camps is mirrored in the methodologies used to research students' conceptions of the characteristics of science: they have themselves reflected a move from predominantly quantitative (experimental-science) dispositions to qualitative (interpretivist-science) paradigms (Lederman, 1992, p. 333).

Given firstly this stand-off between experimental and interpretivist camps as to the nature of reality, in addition to science itself presenting a protean mosaic, defining the characteristics of science is predictably slippery: indeed conceptions of the nature of science are themselves uncertain, developmental, numerous (Kang, Scharmann, & Noh, 2005; Lederman et al., 2002, p. 499) and constructed.

> Certainly, when one considers the differences among the works of [prominent scientific- philosophers such as] Popper (1959), Kuhn (1962), Lakatos (1970), Feyerabend (1975), Laudan (1977), and Giere (1988) it becomes quite clear that there is no singularly preferred or informed nature of science and that the nature of science is as tentative, if not more so, than scientific knowledge itself. (Lederman, 1992, p. 352)

The weak consensus regarding the specific characteristics of science (Clough, 2006, p. 463; W. W. Cobern, 2000, p. 219; Lederman et al., 2002, p. 498; Lederman & Lederman, 2004, p. 37) suggests a need for reflexivity. That is, the characteristics of science believed to be binding or guiding a particular study should ideally be declared therein.

## 2.2 Attempting to define what science-education should do: Incorporation of the nature of science

Reflexivity about the nature of science is also needed within science classrooms to standardise the characteristics of science that will guide instruction. Once there is enough accord regarding these foundational principles, effective science instruction is achievable (Smith, Lederman, Bell, Mc Comas, & Clough, 1997, p. 1103). Such a consensus does exist, for instance, in the United States' National Science Education Standards (National Research Council, 1996), and the NSTA Position Statement on the nature of science (National Science Teachers Association, 2000). Conversely, the Trinidad and Tobago lower secondary school science documents (Ministry of Education, 2008) recommend an "understanding of the nature of science" but do not articulate what these characteristics should be (p.25). Caribbean regional upper-school science syllabi for Chemistry, Biology, and Physics also did not directly refer to the nature of science (Caribbean Examinations Council, 2013a, 2013b, 2013c).

Dissonance surrounding conceptualisations of the characteristics of science though is not necessarily disadvantageous and may present opportunity to make students aware of critical views of science:

> Even in matters having widespread agreement, conceptual understanding rather than declarative knowledge should be sought. This is critical as the point of a progressive education, including an understanding of the NOS, is not to indoctrinate, but to educate students about relevant issues, their contextual nature, and reasons for different perspectives. (Matthews, 1997 as cited in Clough, 2006, p. 464)

Almost predictably, given the lack of consensus within the scientific-community itself, myths regarding the characteristics of science have become pervasive within science-classrooms and throughout the society. Some of the most common myths include that science is a solitary pursuit; that science and technology are identical; that science models represent reality; that the acceptance of new scientific-knowledge is straightforward; that scientific-conclusions are reviewed for accuracy; that experiments are the principal route to scientific knowledge; that scientists are particularly objective; that science and its methods can answer all questions; that science is procedural rather than creative; that science and its methods provide absolute proof; that evidence accumulated carefully will result in sure knowledge; that there is a general and universal scientific-method; that a hypothesis is an educated guess, and finally, that hypotheses become theories which in turn become laws (McComas, 1996).

Observation reveals that many of these myths focus on products of science in the form of laws, models, methods, technologies and so on, and hint that there may be a pervasive societal awareness of science as experimental as opposed to interpretivist. It really is an age-old battle against Comte's positivism fought on many fronts since the mid-20th century through the anti-positivist challenges of Popper, Lakatos (Bird, 2003, p. 127) and Kuhn (Bird, 2003, p. 125).

This lack of consensus surrounding the characteristics of science within the scientific-community and the society has also registered in classrooms, with students and their teachers continuing to demonstrate a misunderstanding of the characteristics of science across time (Bady, 1979; R. Duschl, 1990; Lederman, 1992; Lederman et al., 2002; Mackay, 1971; Mead & Metraux, 1957; Miller, 1963; Ryan & Aikenhead, 1992; National Science Teachers' Association, 1962).

A large contributing factor to a misunderstanding about the characteristics of science is an ignorance of the History and Philosophy of Science (R. A. Duschl, 1985). However, even when teachers hold proper understandings of the characteristics of science, these understandings do not necessarily influence their pedagogy (Abd-El-Khalick et al., 1998). To begin to foster stronger understandings of the nature of science within classrooms, Abd-El-Khalick et al. have derived a few recommendations for teacher-training. They suggest that teachers still need to be convinced of the rationale for teaching the characteristics of science (especially since they may think that teaching these characteristics undermines their main aim of teaching science (Clough, 2006, p. 486)). They suggest too that teachers' experiences assessing the characteristics of science be expanded, and that the characteristics of science be more strongly represented in field practices (Abd-El-Khalick et al., p. 431). Lastly, they, (along with Akerson & Volrich, 2006; Clough, 2006; Khishfe & Abd-El-Khalick, 2002; Lederman et al., 2002; Schwartz, Lederman, & Crawford, 2004), support that pedagogy be planned to explicitly teach about the characteristics of science, and that students' understandings of the characteristics of science should not primarily arise from their implicit inductions drawn from classroom activity. Clough (2006) further advocates, (and the work of Liu & Lederman, 2007, p. 1281, with Taiwanese science-teachers supports), the use of contextual experiences to help students to develop "robust understandings of the NOS that can be applied in a variety of settings" (p. 489).

Certainly, an appreciation of the characteristics of science has for a long time been considered key to science-education reform, and to scientific-literacy (American Association for the Advancement of Science, 1990, 1993; National Research Council, 1996; National Science Teachers' Association, 1962). Scientific-literacy can be considered as the passport that citizens use to comfortably navigate a world increasingly dominated by scientific products and ideas and scientific-literacy certainly is now "deemed necessary for an effective and satisfying life" (Moore, 1995, p. 1).

### 2.3 Attempting to define what science-education should do: Aims of science-education and scientific-literacy

Extra-regional goals for science-education include the United States' (US) efforts towards "Science for All" and the United Kingdom's goals towards a "Public Understanding of Science" (R. Duschl, 2008, p. 268).

Within the US too, The National Research Council (National Research Council, 2007) views science as an integral part of human culture and one of the zeniths of human capacity. They suggest that science will either be career or hobby and that science-education should then provide experiences to develop the habits of science such as language, and logic and problem-solving skills. They further propose that the citizenry of a democracy should possess an understanding of both science and its methodology so that they can make useful decisions for themselves and their community regarding scientific-information. Lastly, the Council suggests that science-education is necessary to develop technical and scientific know-how to secure economic competitiveness and fulfill national needs (p.34).

At home, the goals for science-education are similar. The aims of the national lower secondary integrated science syllabus of Trinidad and Tobago are to "stimulate students' curiosity and creativity; develop competence in the use of the knowledge and methods of science; [and] develop students' critical awareness of the role of science in everyday living" (Ministry of Education, 2008, p. 21). Regionally, for upper secondary science, the Caribbean Examination Council rationalises the teaching of science since

> The application of scientific principles and the conduct of relevant research are of significant importance in identifying, assessing and realising the potential of the resources of Caribbean territories. A good foundation in the sciences will help citizens of the Caribbean to respond to the challenges of a rapidly changing world using the scientific approach....It [science] contributes to the development of the Ideal Caribbean Person as articulated by the CARICOM [Caribbean Community] Heads of Government in the following areas: respect for human life, awareness of the importance of living in harmony with the environment, demonstrates multiple literacies, independent and critical thinking and the innovative application of science and technology to problem solving. In keeping with the UNESCO [United Nations Educational, Scientific and Cultural Organization] Pillars of Learning, on completion of this course of study, students will learn to do, learn to be and learn to transform themselves and society. (Caribbean Examinations Council, 2013b, p. 1)

A compilation of the international, regional and national aims of science-education discussed above can hence be argued to fall into three broad categories of goals – "*the conceptual structures* [often the laws of experimental-science] *and cognitive processes* used when reasoning scientifically; *the epistemic frameworks* used when developing and evaluating scientific knowledge; and *the social processes and contexts* that shape how knowledge is communicated, represented, argued, and debated [that is the interpretivism that makes meaning in science]" (R. Duschl, 2008, p. 277). [italics added]

Some general goals of scientific-literacy that mirror the aims for science-education discussed above include to facilitate

> the production of a highly skilled labor force (Black & Atkin, 1996; Gilbert, 1994, McGinn & Roth, 1999); to create an internationally competitive pool of scientists (Fensham, 1997; Woolnough, 1997); to encourage gender and multicultural equity (Kahle, 1996; Krugly-Smolska, 1996); and to promote socio- political, civic, and democratic competency (Hodson, 1994; Hurd, 1998; Longbottom & Butler, 1999). (as cited in Yoon, 2008, p. 2)

In keeping with Geertz's cultural conception as a web of meaning from which one cannot be extricated as one makes sense of the world, I embrace by extension that scientific-literacy too is need-driven so that a physician, chemistry teacher, person living in the tropics of Trinidad and Tobago compared to the temperate zones of the US, and policy makers, all need varying literacies of science (Moore, 1995, p. 1; Wolff-Michael & Lee, 2004, pp. 265-267) to navigate their peculiar world-space or context.

Supportively, the use of experimental-science's technological products, for instance digital media and information communication technologies, are usually only adopted once users perceive that they will support their context and make their lives easier, not simply because these technologies are easy to use (Adam, 1998; Adams, Nelson, & Todd, 1992, p. 237; Davis, 1989, p. 333). Adopters also tend to use such new technologies to supplement rather than replace their activities (Economic and Social Research Council [ESRC], 2000, p. 4). By extension then, the society seems concerned with the products of science for self-serving reasons and may hence be understandably more familiar with science-as-experimentation. Possibly too, society's focus on the utilities of science might be response to its confusion or ignorance of the epistemological routes (interpretivist-science) by which science derives meaning.

Society may in many arenas be giving the scientific process free reign once it continues producing the goodies needed to appreciate its lifestyle: that is, it has an unspoken "ends-justifying-means" contract with experimental-science. Indeed, experimental-science's production of technological goodies has proven that knowledge-making can be a lucrative business. Societal wonder with scientific-product may also be reflecting moves in science away from an endeavour of humanity coming-to-know itself and its surroundings (interpretivist), to a commercial enterprise placing greater emphasis on products of research and development (experimental), business partnerships and income streams, and intellectual property at the expense of teaching and service, and the free exchange of ideas (Krimsky, 2006, p. 22).

Science-education then should produce a scientifically-literate person capable of navigating a world dominated by the scientific-enterprise, and appreciative of the ways in which science comes to know- including the role of contextual factors on the creation of scientific-knowledge. Indeed, contextualisation is especially important for spaces, such as the Caribbean, which lie outside of the Euro-American mainstream and whose traditional ways of doing science and coming-to-know about the world tend to be largely ignored within conventional science-education.

### 2.4 Attempting to define what science-education should do: Science-education should welcome into its learning-spaces the ways in which the society it is instructing does science in its communal-spaces – a multi-cultural science-education.

*"If [all] students can also learn how the purposes of scientific activity have varied in different cultures and historical times, and how other cultures have developed sciences to meet these purposes, then they can also learn that the form of contemporary Western science is not universal, inevitable, or unchangeable. This kind of understanding is needed to encourage the critical thinking about the purposes Western science has served, and how these could be changed to create future sciences that better meet the needs of the diverse societies that support them" (Stanley & Brickhouse, 1994, p. 396).*

Definitions of what counts as scientific knowledge have been found central to science-education reform (Stanley & Brickhouse, 1994, p. 389), and a viewpoint that context matters opens the door to the consideration of scientific-knowledge as a sociocultural construction (Villegas & Lucas, 2002, p. 25).

Certainly, a universalist epistemology denigrates and justifies the ruin of epistemological systems thought inferior to western modern science (WMS) (Stanley & Brickhouse, p. 392).

WMS is positivist and appeals to a "universalist epistemology" (Stanley and Brickhouse, 1994, p. 387) in which reality is construed as a concrete, singular entity separate from the observer, above cultural or temporal persuasion, and which can be broken into separate parts for study through verificationist methods of justification (p. 390). The gulf is immense between the everyday life world of many cultures and this theoretically isolated world of scientists (Linjse, 1990 and Solomon, 1983 as cited in Ogawa, 1995, p. 589). Within this theoretical world

> [T]he authority of scientific opinion remains essentially mutual; it is established *between* scientists, not above them. Scientists exercise authority over each other. Admittedly, the body of scientists, as a whole, does uphold the authority of science over the lay public (Polanyi, 1969, p. 60).

The everyday life of communities might be better aligned to that of theoretical science through the study of the anthropology of science which can help dislodge the imperialistic and " 'invisible' realm of Euro-American certainties" (Franklin, 1995, p. 168), and to question whether "science [as WMS] is an exclusive invention of Europeans, or have scientific ways of thinking and viable bodies of science knowledge also emerged in other cultures?" (Snively & Corsiglia, 2001, p. 8). Such thinking can be used to expand science-pedagogy past an application of fundamental scientific-knowledge to explain natural phenomena within the students' world (Moore, 1995, pp. 2-3), and to acknowledge the science indigenous to the socio-cultural communities of the learners under instruction. "Indigenous-science relates to both the science-knowledge of long resident, usually oral culture peoples, as well as the science knowledge of all peoples who as participants in culture are affected by the worldview and relativist interests of their home communities" (Snively & Corsiglia, 2001, p. 1).

Indigenous science is sometimes referred to as ethnoscience, which is "the study of systems of knowledge developed by a given culture to classify the objects, activities, and events of its given universe" (Hardesty, 1977, p. 291) .

This type of science-instruction is culturally-responsive (to both indigenous populations, such as the Caribbean Tainos, and to minority populations such as Blacks in white metropoles as examples), and encourages ethnically diverse students towards greater interest, participation and success in science (Bazron, Osher, & Fleischman, 2005, pp. 83-84; Gay, 2002, p. 106). Indeed, "science education is successful only to the extent that science can find a niche in the cognitive and socio-cultural milieu of students." (W. W. Cobern, 1994, p. 7)

Western modern science's (WMS) heavy contribution to the improvement of humankind's quality of life (Brown-Acquaye, 2001, pp. 69-70) has arguably shifted societal attention away from other sciences that have been thought to contribute less to humankind's achievements. The pay-off of WMS, as experimental science, in the form of an improved standard of living – from clean water, to antibiotics, to computers – as previously mentioned, has also seemed to stymie societal interest in interpretivist-science. For sure, scientific-prowess is capable of securing social development (Brown-Acquaye, p. 68), and arguably economic and political leadership too. So much so that dominant world economies, such as the United States, usually possess robust science-education and research agendas (Coleman, 2013, pp. 47-48; "New frontiers," 2013, p.51; Wise, 2013, pp. 45-46). In fact, it was the United States' furor at having been usurped in the space-race by the Russian's launch of Sputnik that first spurred a science-education reform agenda in that country (R. Duschl, 2008, p. 268; Laugksch, 2000, p. 72; Yager & Penick, 1983, p. 463).

Arguably, the vast application, utility and benefit of experimental-scientific knowledge has allowed it to develop a sort of hegemony compared to other knowledges and has caused it to be the focus of a certain amount of disciplinary jealousy. This jealousy seems to emanate from the interpretivist vs positivist paradigm war in which each camp is trying to corner the epistemological god-code (Franklin, 1995 p.166). Even with science's success and societal penetration, many citizens still seem largely unaware, or unconcerned, that the epistemological routes of science are paved largely on western thought and philosophy.

It is within this universalistic, western, standard account of science that global initiatives such as "science for all" are located and there is a real fear that western modern science (WMS) can act as a gatekeeper (Snively & Corsiglia, 2001) and so determine what comes to be regarded as epistemologically sound scientific-knowledge.

Certainly through history there have been positions supporting a universalist epistemology for school science even as they recognise (but not allow into classrooms), the contribution that other cultures have made to WMS. Stanley and Brickhouse (1994, p. 389) discuss the 1992 position of the National Committee for Science Education Standards and Assessment (NCESA) quoted here:

> This is not to say that other cultures have not engaged in intellectual activities that share attributes in common with contemporary science, or that ways [sic] in which contemporary science is right or most productive, but only that it is not within the purview of school science to engage the critique (NCESA, p. 6 as cited in Stanley & Brickhouse, 1994, p. 389)

It is noteworthy that The US Science Education Standards (National Research Council, 1996, p. 201) similarly opines.

Such an ethnically exclusive “science for all” agenda risks becoming a metanarrative that stifles indigenous ways of coming-to-make-sense of the way that the world works (Carter, 2008). Furthermore, science-education is the most prolific societal route through which the induction and creation of new scientists capable of developing the scientific-competitiveness of a society can occur. Initiatives such as “science for all”, in my view, risk becoming a contentious arena given that who controls the curriculum of an international science-education agenda has the potential to become a pied piper of sorts in steering world political and economic policy.

It might be unsurprising then that challenges to western modern science (WMS) as “the science” is part of a wider global change that has begun to question the superiority of western science (Franklin, 1995, p. 167) and philosophy. For many peoples, WMS does not dominate the native ways in which their communities come-to-know the world about them. For such peoples then, there is need to consider at which points the knowledge of WMS is accepted as belief (B. Cobern, 2004; W. W. Cobern, 2000; Smith & Siegel, 2004). That is, at what point does the knowledge of WMS relate so strongly to the daily living (Snively & Corsiglia, 2001, p. 29) within their communal spaces, that their everyday experiences validate WMS as true and allows them to “believe” it or accept it as “true”. This border-crossing (Aikenhead, 1996) moves students between “everyday life and the world of school science” and requires them to deal with “cognitive conflicts between these two worlds”(Ogunleye, 2009, p. 57).

A culturally relevant science-pedagogy working avidly at border-crossing can help to relieve these cognitive conflicts by embracing science indigenous to communities. Multicultural science-education such as this not only promotes tolerance of perspectives but helps students to realise that every culture worldwide has its own science (Ogawa, 1995, p. 585; Ogunleye, 2009, p. 57). To me this can help to empower all students in their diversity – including those who are not members of first-world countries known for their scientific prowess – to consider what a scientist does; about who is validated to do science and construct scientific-knowledge; and to convince them that a scientist, possibly a Nobel-prize winning scientist, can look like the image that they see in the mirror.

Cobern & Loving (2001) also call for an eclectic, multicultural science-education even as they argue against the teaching of a western modern science (WMS) in which indigenous science has been absorbed. They posit that a standard account of science, as is WMS, is inevitable as good science will always be universally applicable. Indigenous knowledges found useful by broader populations are hence also likely to be assimilated into any standard account. They suggest then that indigenous knowledge is better off as a different kind of knowledge that can be valued for its own merits, play a vital role in science-education, and maintain a position of independence from which it can critique the practices of science and the Standard Account.

By extension, such a call seems to advocate a science-pedagogy that allows students to understand WMS, whilst being able to compare and contrast it with their own indigenous scientific practices (Snively & Corsiglia, 2001, p. 26). To facilitate, teachers are advised to employ cultural scaffolding – that is, the use of the students' "cultures and experiences to expand their intellectual horizons and academic achievement" (Gay, 2002, p. 109). In this way students can become literate in both the dominant and indigenous forms of science, principles and procedures of science, and be able "to apply them in novel and personally relevant ways or, for that matter, to challenge them." (Villegas & Lucas, 2002, p. 26).

Remarkably, contentions between standard accounts of science and indigenous science, and between interpretivist and experimental camps, have not prevented science from more or less achieving broad consensus amongst scientists, as well as an ongoing reproduction of "scientific" methods of thinking.

This has occurred in the absence of definition or awareness of hermeneutical procedures (Markus, 1987) implying that science is an acculturated process (Snow, 1959, p. 170). It is noteworthy too that border-crossing is also an acculturation to the standard account of science from indigenous scientific practice.

There is need then for research to help science-education to better portray the epistemology of science. This research should consider the inclusion of an appreciation of the nature or characteristics of science within science-education (possibly through a joint focus that marries cognitive psychology and the History and Philosophy of Science (Duschl, Hamilton and Grandy, 1990 as cited in W. W. Cobern, 1995, p. 287)); the socio-cultural impact on the creation of scientific knowledge (W. W. Cobern); and the indigenous science-knowledge of communities under instruction (Brown-Acquaye, 2001, p. 70).

These suggestions may be especially relevant to regions like the Caribbean for whom local and global do not mean the same thing (Louisy, 2004, p. 287), and whose cultural science, ways of learning science, and history and philosophy of science are under-represented by western modern science. Such research generally, and peculiarly within the Caribbean region, can provide opportunity for reflexivity about the ways in which science is taught and its effect on our conceptions of what counts as science and scientific knowledge; on *us doing* science; and finally *on how we* do science. Though such work has begun in the Caribbean (e.g., George, 1995, 1999; George & Glasgow, 1988; Herbert, 2008), and in other developing countries (e.g., in Africa, see Lowe, 1988; Ogunniyi, 1988; Yakuba, 1992), it is sparse. For the Caribbean surely, such efforts still only superficially represent the scientific practices of our peoples.

## 2.5 What then can we say is in the middle of the road: Interpretivist-Science, and / or vs, Experimental-Science?

*"Each is necessary and none is redundant" (Brown-Acquaye, 2001, p. 70).*

Summarising so far then, science-education should suggestively consider the nature of science within an inclusive pedagogy that credibly represents the exploratory, creative and cultural [interpretivist] ways in which real scientific-endeavour occurs, (as opposed to the prolific didactic, exclusive, positivist [experimental] pedagogy "rendered untenable years ago"(W. W. Cobern, 1995, p. 287)).

This may make science more contextually relevant and culturally appealing to the society that it is intended to serve, and so possibly boost interest in science-education. Indeed, the marked disinterest in science-education and scientific-careers world-wide is already worrying. Concern is emanating from Britain (Kroto, 2007; Office for Public Management (OPM), 2006); Australia (Commonwealth Scientific and Industrial Research Organisation, 2005); The United States (Broad, 2004); Japan (Fackler, 2008); and the 34 OECD Countries (Organisation for Economic Co-operation and Development, 2012, p. 46). The Caribbean Examinations Council has also registered a marked decrease in enrolment for science subjects as compared to other areas of study in 2009 through 2011 (see Appendix 2 in both Caribbean Examinations Council, 2010, 2011)

There are of course those who passionately, and with strong validation, reject a relativist approach to scientific-knowledge creation (Gross & Levitt, 1997). Richard Dawkins, The University of Oxford's Professor for Public Understanding of Science from 1995 to 2008 has famously quipped

> Show me a cultural relativist at 30,000 feet, and I'll show you a hypocrite. ...If you are flying to an international congress of anthropologists or literary critics, the reason you will probably get there--the reason you don't plummet into a ploughed field--is that a lot of Western scientifically trained engineers have got their sums right (Dawkins, 2000).

Ironically, these vehement rejections of an anti-positivist nature of science seem rooted in identification with science as a culture, a way of doing things, and so immediately disqualifies the notion that science is acultural (Franklin, 1995, p. 165) and non-interpretivist.

A further clue as to why science is thought so strongly to be purely positivist might be its avid use of the hypo-deductive method. Karl Popper claimed that falsification was a superior method to empiricism and logic to justify knowledge as scientific (as compared to superstition say). Falsification allows for theories of science created by induction to be tested through deductive, verificationist experiments attempting to replicate findings and so possibly validate or refute scientific-knowledge via peer review (Monk & Dillon, 2000, p. 77). Hence, ironically, scientific-knowledge is considered reliable once it is unable to be falsified: making scientific-knowledge understandably tentative (National Research Council, 1996, p. 201; Stanley & Brickhouse, 1994, pp. 390-391).

When utilising the hypo-deductive method the successful, independent, reconstruction of findings from any experiment by members of the scientific-community across global and cultural space suggests a fixed-truth independent of the personal suasions inherent to interpretivism. Ironically, scientists are not expected to be unbiased, but over time "the processes of peer review and scientific methodology are assumed to provide an adequate means for correcting and distorting influences" (Stanley & Brickhouse, 1994, p. 388). For sure, "science supports its claim to truth by its spectacular ability to make matter and energy jump through hoops, and to predict what will happen and when" (Dawkins, 2000).

I think that Berry's (2009) position is a good summary to this section. Berry (p. 362) quotes Hamlet in justifying his middle-of-the-road position: "There is nothing either good or bad, but thinking makes it so" (Shakespeare: Hamlet, Act II, scene ii). I agree with Berry and suggest that in the middle of the road there should be

> a dual approach, accepting both the natural sciences [experimental-science] and cultural sciences [interpretivist-science] ways of advancing our knowledge of human behaviour in context. I [Berry] argue that dismissing the positivist traditions of the natural sciences, and replacing them with social constructionist concepts and methods is a regressive step in our search to improve our understanding of acculturation. (Berry, p. 362)

## Section 3: Conclusion

Citizens whose scientific-literacy does not afford them a view of science as both interpretivist and experimental may continue to misunderstand or be disinterested in the characteristics of science. Citizens whose communal, everyday practices of science continue to be locked out of science classrooms may most likely see little relevance in science. These scenarios can retard them from exercising the full gamut of their scientific-literacy. Within an environment increasingly governed by science and its practices, they might continue to revel in experimental-science's goodies, but remain stymied in their ability to contribute to, and direct, the communal and political policy governing the processes through which science derives or induces knowledge about the world around us.

What is surely needed is greater inclusivity and societal awareness of the dichotomous modality through which science works.

Accepting science to be eclectic welcomes benefits from possibilities generated by each side of its duality – in addition to the well-managed tension between the two that stimulates argument, new ideas, and growth about the ontological and epistemological concerns of science. Surely,

*"This polarisation [of interpretivist-positivist] is sheer loss to us all. To us as people, and to our society. It is at the same time practical and intellectual and creative loss" (Snow, 1959, p. 171).*

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