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Science teachers from non-Western backgrounds challenged by (Western) science: A whole other ball game

Abstract:
The apparent Western predisposition of modern science is well established in the literature. Scholars, over half a century, have argued that North Atlantic White male Caucasian values and beliefs have governed scientific thought and the processes of scientific inquiry. An extensive number of studies document the challenges that young learners from non-Western backgrounds encounter when they become students of (Western) science. There is, however, a prevailing assumption that these challenges cease to exist as those learners grow older. In fact, few studies, if any, mention such challenges encountered by science teachers from non-Western backgrounds. This paper describes some of the unique challenges experienced by science teachers from Sri Lanka and Indonesia when they constructed scientific knowledge in the context of in-service professional development. The findings revealed that science teachers from non-Western backgrounds did experience difficulties when they crossed cultural-frontiers. For instance, the teachers preferred practices that were endemic to the traditional teaching of Western science, and they resisted attempts to alter their perceived ideas of Western scientific knowledge. It is possible to conclude, therefore, that science teachers from non-Western backgrounds continue to be challenged by Western science, although the challenges they encounter are different to those of non-Western students.

Key words: Western Science, Non-Western Learners, Professional Development, Cultural-frontiers, Compartmentalization, Australian National Centre for the Public Awareness of Science

Background

School science

The apparent Western ownership of science confronts and disadvantages students from non-Western backgrounds. For instance, students from non-Western backgrounds are challenged by science content to which they are unable to relate (Costa, 1995). This is evidenced in their use of phrases like “the world of chemistry” (p.313) to describe bodies of decontextualized scientific knowledge. To them, school science represents a foreign world that is incongruent with their daily lives and own cultures. One such example by Akatugba and Wallace (2008) of West African students grappling with the concept of proportional reasoning is quoted below:

> While adolescents in western countries use proportional reasoning in everyday activities, such as in the use of road maps, cooking recipes, comparison shopping in price per kilogram, fuel economy, and unit prices, adolescents in many developing countries rarely engage in such activities. In Nigeria, for example, shopping is done mainly by bargain and haggle, while successful cooking is done by mental calculations, tasting, and experience. (p.16)

In order to survive, students from non-Western cultures are compelled to compartmentalize their learning of science. This is primarily because science presents itself as a “Western cultural icon of prestige, power, progress, and privilege” (Aikenhead, 2001a: p.31). Many non-Western students, therefore, learn science in school assuming that it would guarantee better employment prospects and other social benefits (Waldrip & Taylor, 1999). The Relevance of Science Education (ROSE) Project confirms that non-Western students feel compelled to learn science because of the higher social status it offers (Sjøberg & Schreiner, 2005). Other contemporary studies (see, for example, Koren & Bar, 2009) find, correspondingly, that students in non-Western nations, particularly under-developed countries, foster seemingly positive attitudes to school science. However, the scientific knowledge they construct in the classroom remains separate from their own cultural constructs (see also Pamba, 1999).

Non-Western students’ attempts to learn science by compartmentalization could conflict with the traditional cultural constructs in those students’ immediate environments (Phelan, Davidson & Cao, 1991; see also Hodson, 1999; Pauka, Treagust & Waldrip, 2005). Bridging between unfamiliar concepts in school science and the familiar “world-views, identities, and mother tongues” at home (Aikenhead, 2001b: p.338) is a challenge that disadvantages students from non-Western cultures. As Aikenhead (2001a) states elsewhere:

> Because science is necessarily embedded in a culture, science does not transfer easily into other cultures…This problematic transferability was amplified by communication problems that arose when Western science was taught to a non-Western public. Western science, with its own set of norms, values, beliefs, expectations, and conventional actions, turns out to be only one way of making sense of nature. (pp.41-42)

While cultural self-identities make learning science a cross-cultural experience, it can sometimes confront students from non-Western cultures by creating cultural-frontiers, which are represented by science classrooms, practical laboratory classes and even in the general discourse that accompanies school science (Kawasaki, 1996; Larochelle, 2002, Ogawa, 1995). For some students, these cultural frontiers can become symbolic sources of violence, where they “feel their world views threatened by the content and discourse of science teaching” (Palmer, 1999: http://www.ul.ie/~childsp/CinA/Issue60/TOC28_Crisis.htm, Retrieved August 2006). By asking the class a question, for example, a teacher may seem to enforce white (male) values of competitiveness and self-confidence, which could translate into intimidation felt by non-Western (and female) students (Johnson, 2007). As Phelan *et al.* (1991) explain:

> It is when people begin to feel a degree of psychological discomfort with another subculture that border crossing becomes less smooth, and needs to be managed. Contributing to their discomfort may be some sense of disquiet with cultural differences or their unwillingness to engage in risk-taking social behaviour…When the self-esteem of

> people is in jeopardy… border crossing could easily be hazardous. (p.26)

Western image of science

An uncontested single Western view towards science marginalizes a considerable proportion of students worldwide (Aikenhead & Ogawa, 2007). However, it might seem reasonable to expect school science to endorse Western values. Concurringly, an important element of science since the 16th Century has been its strong Western characterisation (McMullin, 1990). Despite secular knowledge extricating itself from Christian belief systems in the early 17th Century, a strong Western presence has continued to dominate all realms of science since the inception of the Royal Society and the subsequent scientific revolution (Gascoigne, 1990).

Historians believe that the fall of Muslim Spain and the separation of the Jews, which permitted Christian supremacy in affairs of governance, may have caused a Western presence to engulf all intellectual pursuits at the time (Huff, 1995; Sarton, 1948). In this climate, it would have been unconceivable to assume anything other than a Western-Christian presence for science. Sadly, historians add, any claims to the Eastern origins of science were gradually disowned while *science*, as we see it today, adopted an exclusively Western image and discarded its oriental garbs.

Second, the Western inclination of science is ascribed to the historical over-representation of achievements by North Atlantic Indo-Aryan races (i.e. “North Atlantic white Caucasian male science”, Harding, 1991: p.209). As the eminent historian Sarton (1948) explains:

> Universal histories have been almost exclusively devoted to the achievements of the Indo-Aryan race. Everything in them gravitates around the development of Europe. Of course this point of view is absolutely false. The history of (hu)mankind is too obviously incomplete if it does not include, on the same level as the Western experience, the immense experience of the East. (p.56)

Euro-centric teaching of school science makes little effort to inform students about the historical contributions to modern science from non-Western traditions (Khan, 2006). For instance, while students learn about Europe during the Dark Ages (600 - 1600 CE); they seldom hear of the scientific, technological and engineering advancements of non-Western societies at that time. More importantly, school science fails to mention that these latter movements heralded the Renaissance in Europe. As Khan from the Science Museum in London explains:

> Isaac Newton, Charles Darwin and Albert Einstein. The chances are that if you try to remember which scientists you were taught about at school, these names will be on your list. But how many students will learn about scholars from non-Western civilisations, such as Ibn al-Haitham, a Muslim scholar of optics who first developed the laws of light reflection and invented the pinhole camera in the 11th century? Or Ibn Nafis, who first recorded observations on pulmonary blood circulation, a theory attributed to William Harvey 300 years later? How about Abbas ibn Firnas, who made the first attempt of human flight in the 9th century, using adjustable wings covered with feathers? And

> how many would know of Zeng He, the Chinese Muslim admiral who used refined technology to construct fleets of massive non-metal ship vessels five centuries ago? (http://www.scienceinschool.org/2006/issue3/missing, Retrieved February 2007)

While African, South and Southeast Asian scientific traditions are equally significant to produce a complete historical account of science, some argue whether non-Western traditions constitute science proper, or if they are merely technologies (see, Needham, 1969; Razaullah Ansari, 2002; Van Sertima, 1983). British colonial records until the 19th Century, for example, maintained a substandard view of non-Western medical practices, thus endorsing the mistaken understanding that empirical inquiries and intellectual pursuits of non-Western peoples do not constitute science (Mahroof, 1998).

> In the Western story, Third World peoples appear as primitives, as children, as barbarians and savages, as outside of history and culture, with no redeeming cultural achievements. They are an obstacle to human progress and a threat to the West unless they are supervised by Westerners. (Harding, 1991: p.237)

To acknowledge that Western science is the only credible form of science is harmful (Keita, 1977). Not only does it disregard the numerous empirical and intellectual traditions fostered by other cultures, but more importantly it advances the notion that science, as we see it today, developed exclusively in the West. Fragmented origins stories, such as the popular belief that Egyptian and Greek sciences are more closely related to Europe than Africa, further advantage Western ownership of science (Harding, 1991).

Third, it is reasoned that Western ownership of science is based solely on political and economic motives (Goonatilake, 1987; Shiva, 1997). In order to ensure Western supremacy, significant scientific and technological advances in the Third World need to be continuously absorbed into North Atlantic economies. Scientists in the Third World are, therefore, trained to communicate exclusively with audiences predisposed to Western beliefs and values

> Third World scientists are led to speak and write primarily to and for an audience of Western listeners and readers; the intellectual and technological world systems make it unreasonable for them to be primarily interested in Third World audiences. (Goonatilake, 1987: p.890)

For example, scientists and engineers in South Korea believe that being able to communicate in English is crucial, if their scientific knowledge is to be accepted and recognized (Hwang, 2005). Since they are non-native speakers of English, Korean scientists and engineers perceive their status secondary to mainstream science and innovation in English-speaking Western countries. This leads to a depreciated view of their own culture (which results, Hwang states, in many senior scientists and engineers from Korea seeking junior positions in North Atlantic institutions).

The forth reason, as Morris (2010) argues, is relative global geography, which advantages the apparent Western ownership of modern science. Following the fall of agrarian empires located along the “lucky latitudes” from Rome to China, in which science flourished previously, modern scientific advancements are located predominantly in the Northern trans-Atlantic; i.e. the West. Although cold climatic conditions may have prevented these regions historically from developing into agrarian empires, their geography enabled later development of powerful and affluent maritime economies across the Atlantic. As Stewart (2010) explains:

> It was the Europeans…who created a new kind of market economy, exploiting comparative advantages between continents…A chain of intellectual breakthroughs followed, generating better ways of measuring and counting, and cracking the codes of physics, chemistry and biology. This fuelled a scientific revolution in Europe (p.34)

It is possible to summarise, therefore, that world histories, historical representations, political and economic motives as well as the advantages of global positioning have permitted a western ownership of science that is taught and learnt today's classrooms.

Non-Western learners and Western science

Tendencies to communicate science exclusively with Western audiences even permeate the science classroom, thereby making school science foreign to students who do not share Western values and beliefs (Aikenhead, 1996). Learning science demands, therefore, an alteration of personal identities and belief structures from students who are not from North Atlantic cultures.

> Students conceptualise science as consisting of superior words and concepts but are often unable to relate these terms and concepts to their life experiences…While they might have a superior attitude to what science can do, they fail to internalise the real meaning and value of using science to understand their world. (Waldrip, Timothy & Wilikai, 2007: p.120)

Personal meaningfulness of school science assumes an entirely different dimension of complexity with non-Western students (Aikenhead, 1996). Aforementioned Western presence and ownership of science contribute to make school science unappealing to non-Western students. The assumption prevails, however, that as these challenges diminish or cease to exist when non-Western learners grow older. In fact, few studies, if any, document the challenges encountered by science teachers from non-Western backgrounds (see, for example, Chinn, 2007; Ogunniyi, 2007a, Ogunniyi, 2007 b). This paper describes cross-cultural observations in two professional development workshops offered to science teachers in Sri Lanka and Indonesia. While some of the observations could be explained from the literature cited previously, I believe that the following findings offer new cross-cultural perspectives in science teacher education.

The Study

The Australian National Centre for the Public Awareness of Science (Australian National University, Canberra) offers one-day workshops to secondary school science teachers in Australia and overseas. I studied six workshops using a series of observational variables derived from Flanders Interaction Analysis System (Gall, Borg & Ball, 1996). Of these workshops, two were offered to science teachers from Sri Lanka (sixty-six teachers) and Indonesia (nine teachers). During the two workshops, I recorded elements that were not observed in the workshops for science teachers in Australia. These observations did not, however, constitute separate categories of observational variables. Instead they featured alongside the workshops' communications that were described by the six categories of observational variables[1]. Those observations, which are essentially cross-cultural perspectives, were recorded as extensions to the workshops' communications.

Findings and Discussion

Asking questions

The Sri Lankan and Indonesian teachers did not respond immediately to the questions that were asked by the facilitators (i.e. Category 1: Question causing teachers to reflect about their existing scientific knowledge). Sometimes the facilitators encouraged the teachers to respond by offering supporting information, such as diagrams that complemented the questions. The teachers seemed to anticipate the facilitators' supporting information, as if wishing to have surety before they committed their answers.

When the teachers did respond, they used precise statements that were different to the spontaneous, open-ended replies by the Australian teachers in the other workshops. Moreover, the Indonesian and Sri Lanka teachers' replies relied heavily on technical and scientific vocabulary, which attempted to answer the questions *correctly*. Also, not all of these teachers responded to the facilitators' questions. Many of the teachers relied on their peers to be spokespersons during the workshops.

The literature states that learning science creates cultural-frontiers for learners from non-Western backgrounds (see Aikenhead, 1996). For the science teachers from Sri Lanka and Indonesia, it would seem that, such cultural-frontiers were represented by the above question-answer discourse. One challenge suggested for non-Western learners to negotiate cultural-frontiers is the seemingly alien nature of Western science (see Costa, 1995). This was not the case with the Sri Lankan and Indonesian science teachers in the present study. Although these teachers' were from non-Western backgrounds, they were familiar with Western scientific knowledge from their formal scientific training. The reasons offered by the literature for non-Western students could not be used, therefore, to explain the present teachers' reluctance to respond to questions in Category 1 communications.

It is possible, instead, to explain these observations more accurately based on conflicting values in Western culture and the present teachers' cultural backgrounds. The literature states, for example, that asking questions to elicit information endorses Western values (see Johnson, 2007). Therefore, the present teachers would have been uncomfortable (even threatened) by the facilitators' questions. This may explain the

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[1] I developed six categories of observational variables to record workshop observations:
Cat.1. Question causing teachers to reflect about their existing scientific knowledge
Cat.2. Statement informing teachers about the accuracy of their scientific knowledge
Cat.3. Reference informing teachers about a particular scientific concept
Cat.4. Activity informing teachers about a particular scientific concept
Cat.5. Reference that scaffolds teachers' newly-constructed scientific knowledge
Cat.6. Demonstration that scaffolds teachers' newly-constructed scientific knowledge.

time interval the teachers required to adjust before they responded; and why some teachers alleviated the treat by responding through intermediaries.

Also, the teachers' anticipation of supporting information from the facilitators to help answer questions may allude to their need, as non-Western learners, for visual and auditory cues to assist crossing cultural-frontiers (i.e. "moving back and forth between the culture of Western science and the cultures of the audience", Aikenhead, 2001a: p.39). As mentioned, the present teachers were familiar with Western science. They did not require supporting information to help them move between the culture of Western science and their own cultures. Instead, I believe, if the supporting information assisted in crossing cultural-frontiers, it did so by helping the teachers to move between the culture of Western science and their perceptions of that culture. It appears, therefore, that the cultural-frontier represented by Category 1 communications challenged the teachers with hazardous elements that were uniquely distinct from those documented in the literature for non-Western students (see Phelan *et al.*, 1991).

Comprehending in mother-tongue

Although the workshops were conducted in English, the present teachers communicated predominantly in either Sinhalese, Tamil or Bhahasa (i.e. mother-tongues). They refused offers to translate workshop communications formally, stating that they had sufficient comprehension to understand the facilitators' communications in English. To corroborate, it was observed that the teachers wrote down notes in their respective mother-tongues while listening to the facilitators' discourses in English; thus indicating that they relied on their mother-tongues to comprehend workshop communications. To construct scientific knowledge based on one's mother-tongue is a challenge when scientific information is communicated across cultural boundaries (see Aikenhead, 2001a). This may also explain why some of the teachers depended on peers to respond of their behalf during Category 1 communications.

Challenging alternative conceptions

The Sri Lankan and Indonesian teachers resisted the facilitators' attempts to address alternative conceptions (i.e. Category 2: Statement informing teachers about the accuracy of their scientific knowledge). For example, the Sri Lankan teachers were unprepared to accept the inaccuracy of the textbook illustration used popularly to show fluid pressure increasing progressively with depth (Figure 1). They rejected the possibility of alternative conceptions being advanced through textbooks. They argued, moreover, using fluid pressure laws (i.e. the pressure would be greatest at the deepest point) to corroborate the textbook illustration: that the hole closest to the base of the vessel should project water the furthest.

This observation supports that school science challenges non-Western learners' worldviews (Costa, 1995). It must, however, be clarified that the present teachers were not threatened by the scientific principle of fluid pressure increasing with depth. Instead, they were confronted by the possibility of fostering inaccurate understandings about science: particularly that textbooks could be *wrong*. This observation highlights, first, that teachers depend on textbooks as a source for accurate scientific information (see Anderson, 2002; Wong & Wong, 1998).

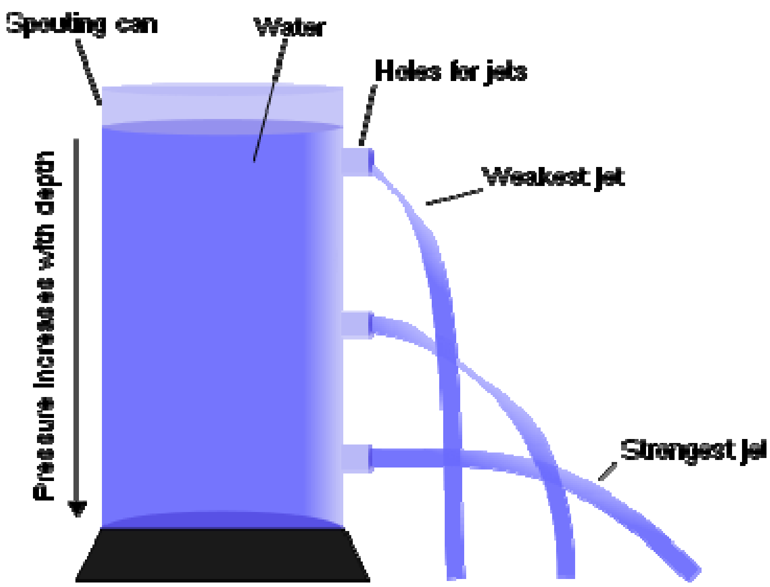

Figure 1: A diagram which apparently shows that pressure increases progressively with depth

Second, and more relevant, is the Western characterization of science that prides itself on being contestable (see Mason, 1953). Scepticism and questioning, for example, which endemically frame scientific understanding, characterise the progression of science (see Sutton, 1996); and have become regarded as characteristics of modern Western science (see Sarton, 1948). The same values are not necessarily shared by non-Western societies (see Harding, 1991), who may not be predisposed similarly to view scientific knowledge with scepticism. As Ogunniyi (2007a) explains, with reference to implementing a science-indigenous knowledge curriculum in South Africa, teachers from non-Western backgrounds need training to view Western scientific knowledge more sceptically and not to regard science as "the only way of knowing or interpreting an experience" (p.963).

The Sri Lankan teachers' absolute belief in Western scientific knowledge may explain why they refused the facilitators' attempts to address alternative conceptions. Moreover, their confidence in fluid pressure laws indicated that they were not challenged by Western scientific knowledge. Therefore, I believe that Category 2 communications challenged the Sri Lankan teachers, instead, by threatening the confidence to which they had grown accustomed with Western scientific knowledge.

Resisting simple materials

A few of the present teachers did not appreciate the simple materials that were used in workshop activities (i.e. Category 4: Activity informing teachers about a particular scientific concept). Although they admitted that simple materials can be used in scientific demonstrations, they were reluctant to use such devices to explain advanced scientific concepts. Instead, they quizzed the facilitators about designing and developing specialized, conventional laboratory equipment which they believed would effectively demonstrate advanced scientific concepts.

The literature states that teachers need to perceive alternative forms of pedagogy feasibly before they could be accommodated (see Crossley & Guthrie, 1987). Also this observation may be regarded as a limited view of science teaching (see Rennie, Goodrum & Hackling, 2001), with ingenuity lacking on the part of the Sri Lankan and Indonesian teachers. I believe, however, this observation highlighted a cross-cultural viewpoint.

Like most non-Western learners, the present teachers may have fostered beliefs of superiority associated with Western science (see Aikenhead, 2001a; Waldrip & Taylor, 1999), usually taught using conventional laboratory equipment. To enable construction of Western scientific knowledge, they would have needed to compartmentalize aspects of their own cultures (see Pamba, 1999) including simple materials around their homes. Therefore, to ask the teachers to revert to these simple materials to teach science would, essentially, question their beliefs of the superiority of Western science. It is probable that the present teachers' resistance, to the simple workshop materials used to demonstrate advanced scientific concepts, stemmed from their beliefs as non-Western learners of Western science.

A similar perspective is shared by Chinn (2007) with reference to non-Western science teachers' negative regard for indigenous practices and knowledge, which may have resulted from compartmentalization of home cultures and superiority beliefs attributed to Western science. These findings suggest that science teachers from non-Western backgrounds need to be exposed to decolonising methodologies where they would learn to reform their science instruction to suit local cultures and to develop greater awareness about sustainable teaching and learning practices.

Separating science from home

The teachers in the present study were presented with demonstrations to help them contextualise scientific concepts in their everyday surroundings (i.e. Category 6: Demonstration that scaffolds teachers' newly-constructed scientific knowledge). During one such demonstration, the facilitators remarked that the teachers could use similar activities to engage guests "at their next party". The present teachers were disconcerted that school science demonstrations could be used outside the classroom. While they agreed that school science should ideally continue to engage informally, they conceded that science was not taught in Sri Lanka and Indonesia in this way (i.e. Teacher respondent: "We never think that what we learn for science could relate to daily-life, let alone using it to entertain people at a party… It may be okay to do stuff like that in Western cultures."). The teacher reasoned that such an outlook to science was foreign to them. It highlighted the abstractness of school science in non-Western cultures (see Costa, 1995); and emphasised the alienation to which non-Western learners subject their own cultures when they learn Western science (see Pamba, 1999). Similar observations were made by Ogunniyi (2007b), wherein teachers from South Africa regarded their home cultures and the classroom as polar opposites. It was not conceivable for the teachers that the two thought-systems could be compatible and that they could complement each other.

Conclusion

The cross-cultural perspectives that were observed in the workshops for Sri Lankan and Indonesian science teachers support earlier findings in cross-cultural science education research. The reluctance of teachers in the present study to answer questions, for example, has been explained as an unwillingness of non-Western learners to partake in competitive attempts of information eliciting, which are preferred by Western learners.

However, the non-Western learners in the present study were unique in that they were not novices to Western science; i.e. they taught Western science in their classrooms. It is unlikely, therefore, that they were challenged by Western scientific knowledge. Admittedly, their perceptions of science were not the same as non-Western students beginning to learn Western science.

The cultural-frontiers the present teachers encountered in the workshops were different from the ones which previous studies have found with regard to non-Western students. Because of this distinction, the cross-cultural perspectives in the present study offer new insights into the area of science education in cross-cultural contexts.

The teachers' unwillingness to accept that textbooks could advance alternative conceptions, for example, indicated that they were threatened by efforts to address inaccuracies in their familiar Western scientific understandings. These teachers had a high regard for Western scientific knowledge. This was demonstrated when some of the teachers refused to accept simple materials as alternatives for conventional laboratory equipment.

The latter observation highlighted two characteristics of non-Western learners who are comfortable in their understandings of Western science. First, the present teachers were reluctant to surrender practices endemic to the traditional teaching of Western science and to alter their perceived ideas of Western scientific knowledge. Second, the distinction the teachers created between their home and the science classroom obstructed exchange between their own cultures and Western science. This was emphasised in the teachers' confusion about including science demonstrations to entertain guests at a party.

The findings from this study offer new insights to cross-cultural studies in science teacher education by highlighting the unique duality that exist between the home cultures of science teachers from non-Western backgrounds and the comfort to which these teachers have grown accustomed to Western science.

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