

## Expanding the Research Agenda for Scientific Literacy

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Explicitly or implicitly, research questions always relate to education policy and practice, as depicted in Figure 1. The three interact. A fundamental research question for policy and practice is (Roberts, 1988): What counts as scientific literacy today? To help us address this question, Roberts (2007) created a heuristic framework for understanding the defining ideologies of scientific literacy (SL). His framework is a continuum between two extremes, which he calls Vision I and Vision II. At the one extreme, a Vision I policy is scientist-centred and focused on decontextualized science subject matter, with the aim to enculturate students into scientific disciplines (pre-professional training). At the other extreme, a Vision II policy is student-centred, context-driven, with the aim to enculturate students into their local, national, and global communities (as many other school subjects do).

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Figure 1 fits here.

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The *enactment* of Visions I and II policies into practice (e.g., into classroom instruction or into the assessment of students’ SL) is a somewhat different perspective than a policy perspective. Roberts (2007) points out that an enactment of a Vision I policy leads to a Vision I type of practice (e.g., a traditional status-quo school science, or assessments based on a narrowly defined SL). However, an enactment of a Vision II policy has conventionally led to a combination of Visions I and II type of practice. In the world of *practice*, therefore, the choice facing science educators is Vision I versus a combination of Visions I and II (i.e., Vision I-II).

Decades of empirical research unambiguously delineate the following dilemma for educators promoting SL (Aikenhead, 2006a): The choice between Vision I and Vision I-II is, in effect, a choice between (respectively): (a) most students playing school games so it appears as if meaningful learning has taken place yet little SL has been achieved; or (b) most students finding their school science somewhat culturally relevant, and therefore, developing their SL to a measurable degree. The latter choice (Vision I-II) seeks to enhance students’ capacities to function as life-long, responsible, savvy participants in their everyday lives; lives increasingly influenced by science and technology. The former choice (Vision I) has consistently led to decreased interest and lower enrolments in school science. For example, after investigating in depth why so many science-proficient clever students no longer took optional science courses past grade 10, Lyons (2006, p. 308) suggested researchers seriously ask: “Why should they?”

To recap: the choice between Vision I and Vision I-II in practice turns out to be a choice between, on the one hand, decreased enrolments along with little SL achieved by students, and on the other hand, a relevant school science accompanied by a significant increase in SL by students.

The key question, “Why should students enrol in school science?” seriously diminishes the significance of narrow research agendas dedicated to *how* students learn science (e.g., conceptual change). If school science enrolment and SL achievement are sinking like the Titanic, then let us refrain from conducting further behavioural, cognitive, or simplistic social constructivist research on how to rearrange its deckchairs. On the other hand, a learning theory that addresses students’ “knowing-in-action” (Driver & Erickson, 1983) and/or involves their self-identity formation (e.g., Brickhouse, 2001, 2003, 2007; Case, 2007; Brown, Reveles, & Kelly, 2005; Kelly, 2007; Schreiner & Sjøberg, 2007) is highly significant because it suggests an answer to “Why should students enrol in school science?” – They do so in order to create relationships with their world (in grades 6 to 12, at least). This type of research program also harmonizes with cross-cultural ideas on learning and non-learning, such as the third space (Bhabha, 1994) and cultural border crossing (Aikenhead, 1998), respectively; and harmonizes with investigations into cultural processes that extinguish students’ interest in studying school science (e.g., Lyons, 2006; Osborne, 2007; Tobin, 2006; Tytler, 2007).

It is crucial to recognize, however, that the meaning of “science” and the *content* of school science necessarily and dramatically change when we embrace these new perspectives on learning and non-learning. Many authors have not discussed this implication. When conventional, academic, decontextualized science (a Vision I view of SL) changes to contextualized science (a Vision I-II view of SL in practice), the context *and content* are mostly dictated by students’ everyday worlds, rather than by scientists’, teachers’, or curriculum developers’ ideas of appropriate contexts and content for school science (Aikenhead, 2006a; Deng, 2007; Fensham, 2002; Tytler, 2007). Changing the meaning of “science” in the domain of school science takes us beyond policy and practice.

### **Beyond Policy and Practice**

The interactions among research, policy, and practice (Figure 1) do not afford a sufficiently comprehensive structure for a future SL research agenda. The present structure must be expanded. Some scholars have argued from an educational philosophy point of view that Vision I and Vision II are mutually exclusive in science classrooms, and that combining them is detrimental to students (Egan, 1996; Hughes, 2000). However, I concur with Orpwood (2007) and Roberts (2007) that educational soundness is only one consideration in the real world of science education; we also need to address political realities. Educational soundness and political realities are often contradictory (Aikenhead, 2006a).

Research, policy, and practice are all driven by *politics* (depicted in Figure 2). This political dimension includes elitism, inclusiveness, privilege, equity, prestige, funding, allegiances, self-identities, etc.; as well as science teachers’ orientations to SL, students’ expectations of school science, the culture of school science, the culture of schools, parents’ opinions, university science departments’ demands, university regulations, teacher education programs, professional scientific organizations’ self-interests, assessment institutions, etc. (Aikenhead, 2006a; Fensham, 1992). The transformation of a Vision I policy or practice into a Vision I-II policy or practice is, first and foremost, a political event (Fensham, 1998, 2000, 2002; Hart, 2001; Roberts, 1988,

1995). Politics are central to Tiberghien's (2007) "legitimation by a community respected by society," where today each word (legitimate, community, respected, and society) is problematic and contested on political grounds, for both Vision I and Vision I-II types of SL practice. Even the notion that learning involves self-identity formation has political dimensions (Brickhouse, Eisenhart, & Tonso, 2006).

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Figure 2 fits here.

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Fundamental research questions of a political nature related to SL at the policy level include: Who decides on policy? How is the decision reached? How were participants chosen? What were their anticipated roles versus their enacted roles? What actor-networks (Carlone, 2003; Gaskell & Hepburn, 1998) did they bring to the deliberations and what networks developed as a result of the deliberation? Participants' roles and actor-networks could be a primary focus of research into who decides, and how the decision was reached. In short, worthwhile SL research in the political domain would investigate the influence of various stakeholders in the negotiations and decisions over what SL ideology will count as school science.

A preliminary study could evolve into a major R&D project that forges new roles and networks to enhance a clearer and more politically endorsed perspective on enacting a balance between Visions I and II. Such a study could be a "consensus-making R&D" (Aikenhead, 2006a, pp. 130-131). This is action research on the grand scale of deliberative inquiry accompanied by curriculum implementation and evaluation, within a large educational jurisdiction and drawing upon a broad array of stakeholders judiciously chosen so the political elite is represented but its status quo SL ideology is actually discussed and renegotiated.

Scaled-up versions of investigations by Aikenhead (2005), Duggan and Gott (2002), Law (2002), and Symington and Tytler (2004) are needed to help establish a SL policy valued by politically positioned leaders and influential citizens (Elmore, 1996). This type of research will guide deliberations over a Vision I-II type of policy recommended by Roberts (2007), that is, a balance between the two extremes.

Because the prevailing political climate of any educational jurisdiction determines political matters, another crucial R&D action research question for a future SL research agenda arises: How can the political climate of an educational jurisdiction be influenced to achieve a balance of Visions I and II in both policy and practice? How can political support for inappropriate and invalid assessment (Orpwood, 2007) be undermined in the public forum?

Research of a political nature at the level of practice belongs on a future SL research agenda. For example: How do science-proficient students actually use school science content in their everyday lives (if at all) compared with science-shy students, when both groups cope with similar situations? (This line of research converges with Brickhouse's [2007] "Who are scientific literates?") Who in the community is engaged with science and technology in some form or another? How can students and teachers become more scientifically literate through learning from these people, directly or indirectly? How do students, teachers, and administrators come to

value a Vision I-II type of scientific literacy? and Who will allow students to learn science from this perspective?

In summary, it is critical to expand the present research agenda for SL to include a focus on politics. Historically, the politics of privilege and elitism, *not consensus*, has legitimated the ideology of Vision I endemic to science education (Aikenhead, 2006a; Hodson, 1994; Seddon, 1991). This legitimation in the Anglo world goes back to 1867 (Jenkins, 2007), which is being contested at this symposium today by those who eschew the politics of privilege and elitism. Curriculum transformation to Vision I-II requires SL researchers to address *political* goals explicitly as well as educational goals. Defenders of a Vision I ideology are highly political in their response to attempts at curriculum transformation (e.g., Aikenhead, 2002). Therefore, proponents of a Vision I-II ideology need to be politically savvy by placing political research on their SL research agenda. The political success of Vision I-II research agendas will be measured, in part, by the degree to which defenders of a Vision I ideology are co-opted or marginalized in the process.

### Vision III?

In addition to the competing interests between political realities and educational soundness associated with Visions I and II, Roberts (2007) discusses a different dynamic between Visions I and II. He draws upon Solomon's (1998) analysis of one version of Vision II she calls "popular scientific culture," which "refers to the concerns of the public, so important within their own local culture and often having a scientific and technological basis" (p. 170). In the context of contrasting popular scientific culture with academic scientific culture, Solomon asks, "Can [academic] science be taught so that it connects with attitudes, personal values, and political issues? This would indeed make [academic] science a part of popular culture. But would it still be [academic] science?" (p. 171). Roberts (2007) points out, "Such questions express the crux of the tensions between Vision I and Vision II" (p. 754).

Solomon identified *cross-cultural* tensions arising between popular scientific culture and academic scientific culture. In academic scientific culture, scientists collectively work within a subculture that frames their thinking and practice (Pickering, 1992). For most scientists, this subculture is Eurocentric in nature. I find the term "Eurocentric science" more descriptive than "academic science" because it expresses Solomon's cultural considerations more explicitly. Moreover, the term "Eurocentric science" leads directly to a consideration of non-Eurocentric sciences in communities or countries that do not embrace a Euro-American culture. This consideration in turn draws our attention to a variety of long standing indigenous cultures worldwide that have developed ways of describing and explaining nature based on empirical and rational means, but much differently than Eurocentric science.

Conventionally, SL has been restricted to literacy in Eurocentric science (Roberts, 2007), thereby ignoring a world of other sciences (Battiste & Henderson, 2000; Maddock, 1981; McKinley, 2007; Ogawa, 1995). Aikenhead and Ogawa (2007) identify this pluralism of science by the following triad:

- *Eurocentric sciences*: the diverse enterprise of professional scientists, engineers, and people employed in science-related occupations; an enterprise based mainly on: particular values, a plethora of methodologies, Cartesian dualism, anthropocentrism, reductionism, rectilinear time, quantification, and predictive validity established through argumentation and consensus making by a group of practitioners (scientists within a paradigm); in short,

one way of knowing nature. Professional scientists are people employed mostly in a social context of power and privilege associated with R&D, patents, economic progress, and globalization. These professionals are paid by their institutions to generate, transform, or use knowledge for the purpose of benefiting those institutions.

- *Indigenous sciences*: non-Eurocentric ways of knowing nature that have assured the survival of the first peoples who inhabited a locality or place, over tens of thousands of years; for example, ways of knowing nature held by the Sāmi of Scandinavia, the First Nations of North America, and the Māori of Aotearoa New Zealand. These nations historically share experiences of repression and colonization (Battiste & Henderson, 2000; Niezen, 2003).
- *Neo-indigenous sciences*: non-Eurocentric ways of knowing nature held by long standing mainstream cultures that generally have not experienced Euro-American colonization, for example, Islamic, Bhutanese, and Japanese cultures; plus Euro-American commonsense cultures of everyday life (Linder, 1993; Semali & Kincheloe, 1999). The complexity of this category warrants further elaboration in a future research agenda for SL.

When we consider students in non-Eurocentric communities, we ask: *Whose culture is being transmitted in school science in the name of scientific literacy?*

When school science transmits only Eurocentric sciences as it does in both Visions I and I-II (i.e., in a singular-science ideological perspective – Eurocentric SL), many students generally feel alienated by the cultural clash between their home culture and the culture of school science (Aikenhead, 1998; Costa, 1995; Maddock, 1981; McKinley, 2007; Ogawa, 1995; Phelan, Davidson, & Cao, 1991). In their resistance to feeling alienated from, or marginalized by, school science, these students tend to reject instruction in Eurocentric SL. This state of affairs also applies to a large majority of Euro-American students whose self-identities do not relate to the culture of Eurocentric sciences (Aikenhead, 2006a; Cobern, 2000; Klopfer, 1969).

A pluralist notion of science proposed here is consistent with the OECD (2006, p. 21) framework's description of science: "a process that produces knowledge and that proposes explanations about the natural world." For instance, Aikenhead and Ogawa (2007) offer the following pluralist definition of science: a rational empirically based way of knowing nature that yields, in part, descriptions and explanations of nature; where the term *rational* does not signify a universalist rationality, but a rationality founded within the cultural context of use (Elkana, 1971).

The fundamental issue here, of course, is the politics of what counts as "science" in school science. I do not presume that scientists and their professional organizations will take up a pluralist definition of science because their identities seem to rest on their ownership of the word "science," an ownership expressed in terms of a singular universalist view of Eurocentric science (McKinley, 2007). Instead, I presume that a pluralist definition of science restricts itself to the domain of school science. A pluralist perspective for SL requires a careful articulation of several sciences: (1) relevant neo-indigenous sciences; (2) Eurocentric sciences (plural) found in the everyday working world of professional science and science-related occupations (not simply academic science); and (3) where applicable, Indigenous sciences.

Vision I-II policy and practice can be broadened to encompass not only a Eurocentric SL, but indigenous SLs (plural) – both neo-indigenous and Indigenous SLs. Thus, the conventional notion of Eurocentric SL (Roberts, 2007) is not rejected. Instead, it is held as one powerful way

of knowing nature and understanding how Eurocentric sciences tend to operate in students' local, national, and global cultures. Indigenous SLs, related to local ways of knowing nature and understanding the community, will also be relevant for most, but not all, students. The exception here is a student whose personal worldview finds comfort in understanding the world as Eurocentric sciences describe and explain the world. These students comprise a small minority who tend to critique a Vision I-II type of classroom practice, a critique described by Tiberghien (2007).

Some science educators argue that a pluralist approach risks denying non-Eurocentric students the cultural capital that is essential for access to power in their society. In the context of what we now know empirically about the consequences of a Vision I compared to a Vision I-II school science with respect to student alienation, this argument appears to promise cultural capital where it is rarely found (i.e., in Vision I). Thus, the argument postures political symbolism (Rogan, 2007) rather than an education towards cultural capital.

To distinguish between the conventional, singular-science, Eurocentric SL and the proposed plural-science SLs, I suggest we call a plural-science SL ideology "Vision III," thereby adding a third dimension to Roberts's (2007) heuristic framework. Just as Vision II in practice becomes Vision I-II (Roberts, 2007), Vision III in practice becomes Vision I-II-III (Aikenhead, 2001). A Vision III ideology articulates a legitimate future dimension in an expanded research agenda for SL, and it connects with theories of learning (and non-learning) predicated on knowing-in-action.

The political agenda for a Vision I-II type of SL (outlined in the previous section) applies directly to a Vision I-II-III type of SL.

### **Conclusion**

One of the cultural myths associated with a Vision I ideology of Eurocentric SL is the story line that school science accurately reflects professional (academic) science. Many science education researchers, however, lament the misrepresentation of professional science found in Vision I types of school science (e.g., Cross & Price, 1999; Gaskell, 1992; Kelly, Carlsen, & Cunningham, 1993; Knain, 2001; Larochelle & Désautels, 1991; Leach, Driver, Millar, & Scott, 1997; Linder, 1993; Östman, 1996; Solomon, Duveen, & Scot, 1994). "Is it really science?" they ask, which is the same scrutinizing question that advocates of Vision I tend to pose about Vision II (Solomon, 1998). Different questions need to be asked: What types of sciences (professional or academic Eurocentric, neo-indigenous, or Indigenous) are relevant to a particular context? and What political resources enhance researchers' ability to initiate the development and implementation of a Vision I-II-III type of scientific literacy?

School science is a negotiable enterprise, open to debate over what counts as scientific literacy today. Which sciences should be drawn upon in school science to make sense of human situations or events related to understanding natural phenomena? The question assumes a context-driven pluralist-science perspective captured by an ideology of Vision I-II-III. The political realities arising from a Vision I-II-III sense of scientific literacy have already become part of some research agendas (e.g., Aikenhead, 2006b; Aikenhead, Calabrese Barton, & Chinn, 2006; McKinley, 2007).

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Figure 1. Relationships among Policy, Practice, and Research in Science Education

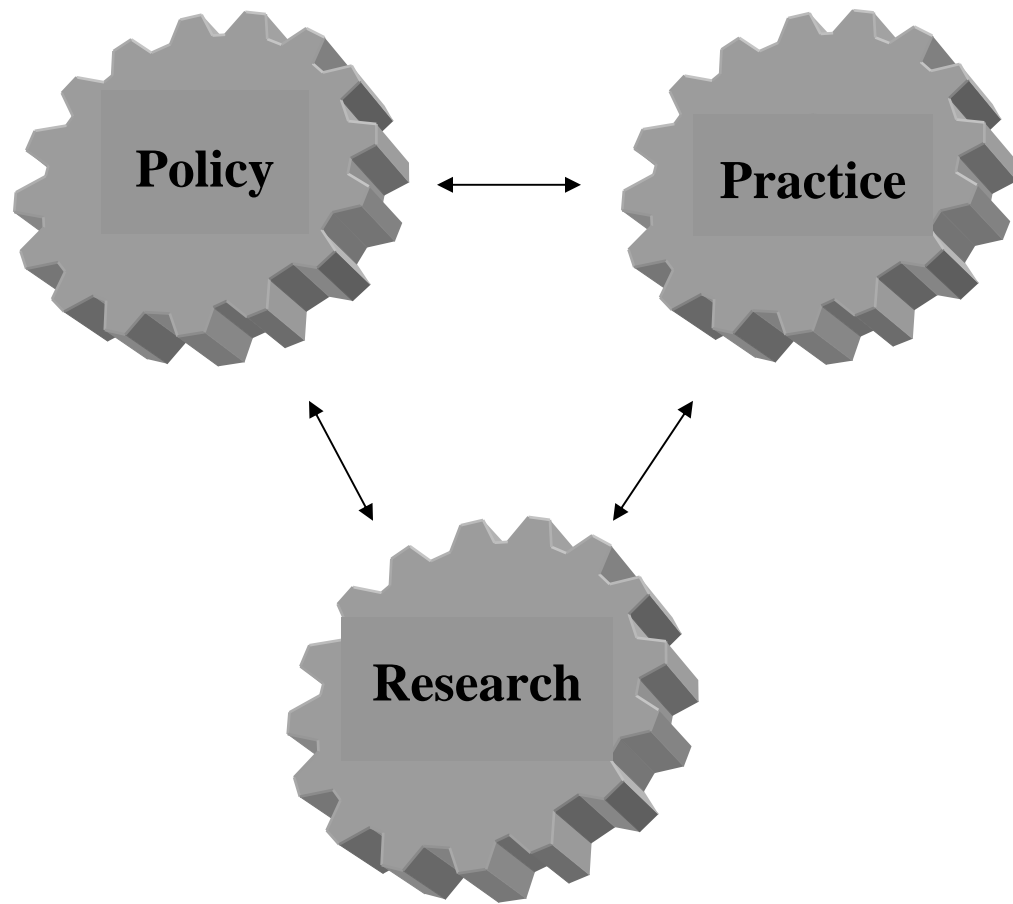


Figure 2. Politics Drives Policy, Practice, and Research in Science Education

