International Journal of Environmental & Science Education
Vol. 4, No. 3, July 2009, 201-213

SPECIAL ISSUE ON SCIENTIFIC LITERACY
Editors: Richard K. Coll & Neil Taylor

On Scientific Literacy and Curriculum Reform

Justin Dillon
King's College London, UK

Received 10 November 2008; Accepted 11 February 2009

Since the first use of 'scientific literacy' in the late 1950s, numerous science educators and policy makers have reconceptualised the term to such an extent that it has been described as being 'ill-defined and diffuse'. Despite this lack of clarity, the term is the focus of curriculum standards in many countries and is at the heart of international comparisons of student attainment including the Organisation for Economic Cooperation and Development's (OECD) Programme for International Student Assessment (PISA) study. Uncritical use of the term masks the existence of deep-seated philosophical clashes that hinder reform of science education in many countries throughout the world.

Key Words: scientific literacies, scientific literacy, educational reform, curriculum

Introduction

Since the first use of 'scientific literacy' in the late 1950s, science educators and policy makers have gradually reconceptualised the term to such an extent that one author remarked relatively recently that "scientific literacy is an ill-defined and diffuse concept" (Laugksch, 2000, p. 71). Despite this perceived imprecision, scientific literacy appears to underpin the curriculum standards of many countries and is at the heart of international comparisons of student attainment (and thus of education systems) including the Organisation for Economic Co-operation and Development's (OECD) Programme for International Student Assessment (PISA) study. But why is something so slippery – so hard to define – treated as if it is the Holy Grail of science education? The answer, it would appear, is that its slipperiness is the key to its longevity.

Whatever your opinion about the utility of the term 'scientific literacy', it would be difficult to argue with McEneaney's (2003) claim that it has a 'worldwide cachet'. In this paper I argue that the term is likely to be part of the discourse of science education for many years to come and that as science educators we need to identify how best to work with it. My analysis is set within attempts to improve science education within a number of European countries and towards the end of the paper, I reflect on how developments in Europe relate to those in other continents.

Underpinning the analysis presented here is a concern that science education frequently benefits the minority of students who go on to become scientists at the cost of those who do not (Osborne & Dillon, 2008). A related concern is that science education is frequently critiqued for its lack of imagination and relevance, and its focus on abstract concepts beyond the

ISSN 1306-3065

http://www.ijese.com/

imagination and interest of most students. These concerns are not new nor are they easily addressed. Members of the 2007 Linné Scientific Literacy Symposium articulated the issues clearly in their "Statement of Concern":

> Science education, perhaps because of the sheer depth and volume of the knowledge base of modern science, has isolated that knowledge from its historical origins and hence students are not made aware of the dynamic and evolving character of scientific knowledge, or of science's current frontiers. There is little flavour in school science of the importance that creativity, ingenuity, intuition or persistence have played in the scientific enterprise. Nor is there any real sense of any meaningful exploration of issues that relate ethical and personal accountability to modern scientific activity. Indeed, the existence of human enterprise that makes science possible is almost ignored in science education. Curricula and assessment need to support teachers' being able to share the excitement of the human dramas that lie behind the topics in school science with their students. (Members of the Linné Scientific Literacy Symposium, 2007, p. 7)

However, their position does not represent those of all science educators. The recent introduction of a new science curriculum aimed at promoting scientific literacy drew criticism from "Leading educationalists [who] criticised [it] for being more 'fit for the pub' than the school room" (BBC News, 2006, 1). The longevity of the term scientific literacy relies on its ability to be seen as an umbrella for radically different philosophies of science education. However, the evidence suggests that when attempts are made to effect curriculum change to promote 'scientific literacy' the unreconciled philosophical clashes hinder progress.

What Do We Know About Scientific Literacy?

Writing at the turn of the century, Laugksch argues that "Scientific literacy has become an internationally well-recognized educational slogan, buzzword, catchphrase, and contemporary educational goal" (Laugksch, 2000, p. 71). Laugksch's paper is a thoughtful conceptual overview and in it he notes that the conceptualization of scientific literacy that he has described hides a range of meanings and interpretations, and he notes that a view has emerged "that scientific literacy is an ill-defined and diffuse concept (e.g., Champagne & Lovitts, 1989)" (Laugksch, 2000, p. 71).

"Ill-defined and diffuse" though 'scientific literacy' may be, the term has survived for half a century, and looks set to outlast 'science for all', and it seems unlikely that another phrase will knock it from its position at the heart of science curriculum policy making (even the rather clumsy "scientific literacy for all" seems to have come and gone (Lee, 1998)). As science educators, we will probably have to live with the phrase no matter how unsatisfactory we find it. It would be more accurate, perhaps, to refer to 'scientific literacies' or 'dimensions of scientific literacy', but more of that later.

Vision I and Vision II: Looking Inward and Outward

In his chapter on scientific literacy in the recent *Handbook of Research on Science Education*, Roberts (2007a) makes an elegant distinction between two ways of looking at the aims and purposes of science education. He identifies two 'visions' for generating conceptions of scientific literacy: Vision 1 and Vision II. Vision I, according to Roberts, "looks inward at science itself – its products such as laws and theories, and its processes such as hypothesizing and experimenting," whereas Vision II "looks outward at situations in which science has a role, such as decision-making about socioscientific issues" (Roberts, 2007b, p. 9).

These visions are underpinned by different philosophies and, at their most extreme, reflect competing interests that have and continue to influence the content of the science curriculum (see Hodson, 2008 for an in-depth study of these issues). At one extreme, there are those whose major preoccupation is the place of scientific content in the curriculum. At the other extreme are those who see science education as being primarily about criticizing the assumptions underpinning science as a cultural activity (see, e.g., Roth & Barton, 2004). These visions, which are philosophically irreconcilable, have established themselves under the increasingly broad umbrella of 'scientific literacy'.

Roth and Barton (2004) powerfully illustrate one dimension of the Vision II philosophy when they argue that:

> Conventional approaches to scientific literacy, knowing, and learning are based on an untenable, individualistic (neo-liberal) ideology that does not account for the fundamental relationships between individual and society, knowledge and power, or science, economics, and politics. (p. 3)

I am broadly in sympathy with that analysis but wherever you stand on the issues, I would argue that scientific literacy (or literacies) will be part of the discourse of science education for a long time. It suits all parties to use 'scientific literacy' as a weasel word.

The job of policy makers and curriculum planners is often to attempt to reconcile these conflicting visions. As a result, they can be put under substantial pressure to promote one vision over another (Blades, 1997; Fensham, 1998). A critical issue for contemporary curriculum makers, though, is can there be a balance between Vision I and Vision II, and do potential scientists need a different balance than everybody else? As Roberts puts it, "Everyone agrees that students can't become scientifically literate without knowing some science, and everyone agrees that the concept needs to include some other types of understanding *about* science [original emphasis]" (Roberts, 2007b, p. 11). It is this logic that allows the competing visions to co-exist under the same banner. In effect, 'scientific literacy' is what Stables (1996) referred to as a 'paradoxical' compound policy slogan. The conflicting visions of scientific literacy are sustained by a series of dubious rationales and questionable assumptions some of which are outlined in the following section.

Rationales for Promoting Scientific Literacy

Drivers for Change

There are several rationales for moving towards scientific literacy as a fundamental goal of science education, and they have all been used by politicians and policy makers in Europe and elsewhere at some point in recent years. To some extent, the drivers are inseparable from the rationales for science education itself. Laugksch (2000) groups the common arguments into two categories which he labels 'macro' and 'micro'. One macro-argument is that "national wealth depends on competing successfully in international markets" and that to compete, a nation must have a strong research and development base. Taking the assumption one step further, a steady stream of home-grown scientists is, therefore, essential to keep the R&D base strong. Such a rational was exemplified recently by Lord Grayson, the UK's new science minister who was quoted as saying that, "Science is fundamental to this country. As we go into this global downturn the importance of maintaining our investment in science has never been greater" (BBC News, December 5, 2008, ¶6).

The opening paragraph of the widely circulated and oft-quoted 'Rocard Report', *Science Now: A Renewed Pedagogy for the Future of Europe,* makes several macro-level assertions such as this one on the opening page:

> In recent years, many studies have highlighted an alarming decline in young people's interest for key science studies and mathematics. Despite the numerous projects and actions that are being implemented to reverse this trend, the signs of improvement are still modest. Unless more effective action is taken, Europe's longer term capacity to innovate, and the quality of its research will also decline. (High Level Group on Science Education, 2007, p. 2)

Another macro-level argument has probably been around even longer than the economic argument. For well over a century, scientists have argued that the public support of science is critical to the continuation of scientific research (Shamos, 1995; Waterman, 1960). Public attitudes towards science and technology have been the subject of repeated study. The 2006 PISA report of a survey of more than 400,000 15-year-old students from 57 countries notes that "92% [of respondents] said that advances in science and technology usually improved people's living conditions" (OECD, 2007, p. 6), and noting that:

> A strong acceptance by students that science is important for understanding nature and improving living conditions extends across all countries in the survey. However, this was mirrored to a much lesser extent in students' responses to the wider socio-economic benefits of science. On average across OECD countries, 25% of students (and over 40% in Iceland and Denmark) did not agree with the statement "advances in science usually bring social benefits". (OECD, 2007, p. 6)

Laugksch also identifies another macro-level argument for scientific literacy which is that the more the public understand how science works and what it can do for them, the more likely they are to support scientific and technological endeavour. Such an argument should cause scientists and their supporters in Iceland and Denmark, in particular, to advocate increasing scientific literacy as a matter of some urgency. However, such a view is based on an assumption that has never really been tested.

Another rationale identified by Laugksch at the macro-level is one that has undergone substantial discussion in the UK. The Public Understanding of Science movement, which was criticized as being based on a deficit model ("if only people knew more science, they'd be more positive about science") has been superseded by a Public Engagement with Science and Technology model that ostensibly encourages public discussion of issues such as xenotransplantation, GM foods and nanotechnology. The espoused argument for increased public engagement with scientists and policy makers is that increased transparency of decision making will lead to greater public confidence in the final decisions made on controversial issues (Royal Society, 1985). Again, this is an assumption that has yet to be rigorously tested.

The final argument listed by Laugksch relates to C.P. Snow's identification, in 1959, of a division between the 'two cultures' of science and literary intellectuals (Snow, 1962). Laugksch (2000) notes that the danger of science being seen as outside mainstream culture is that the public will fail to grasp what science is which might, in turn see them responding to science "with a mixture of adulation and fear" (p. 85). Increasing the public's scientific literacy might help to dispel the perceived 'cult' image of science and scientists.

While the macro-level arguments promote collective economic well-being, democracy and societal coherence, micro-level arguments focus on the benefits of scientific literacy to the individual. To some extent, the micro-level benefits are consequences of the macro-level benefits. The micro-level benefits might include increased economic prosperity and job opportunities, wiser health decisions, increased confidence in science and technology and reduced personal risk. An example of a micro-level rationale is provided by both Shortland (1988) and Snow (1962) who argue that an individual cannot be considered properly educated without a working knowledge of modern science which is one of the major successes of Western civilisation. Such an argument begs the question ‘Who is to say what a ‘proper’ education looks like?’

The Rocard Report’ intertwines both macro- and micro-level benefits of scientific literacy. In a section headed ‘Providing all citizens with both science literacy and positive attitude (*sic*) towards science’ the report is unequivocal about the value of scientific literacy (which it never defines):

> There is *obviously* a need to prepare young people for a future that will require good scientific knowledge and an understanding of technology. Science literacy is important for understanding environmental, medical, economic and other issues that confront modern societies, which rely heavily on technological and scientific advances of increasing complexity. (High Level Group on Science Education, 2007, p. 6, emphasis added)

But the report argues that the ‘key point’ is:

> Equipping every citizen with the skills needed to live and work in the knowledge society by giving them the opportunity to develop critical thinking and scientific reasoning that will enable them to make well informed choices. Science education helps fighting misjudgements and reinforcing our common culture based on rational thinking. (High Level Group on Science Education, 2007, p. 6)

The idea that Europe has a common culture and that it is based on rational thinking might be seen as somewhat simplistic. The strength of the macro- and micro-level arguments for promoting scientific literacy may not be convincing and may rest on some false assumptions. What is important to realise, though, is that the arguments are as much philosophical as they are educational and that, as such, they can drive policy even if there is little evidence to support their veracity (whither ‘rational thinking’?).

Some European Attempts to Make Science Education More Fit for Purpose

Turning now to some European attempts to address the problems of science education in terms of curriculum and pedagogy, I will examine some initiatives in individual nations and some cross-European projects. While the coverage of these initiatives is necessarily brief, I hope to convey a flavour of what has been tried and how it has, or has not, been received.

Britain: Twenty First Century Science

In Britain, the publishing of *Beyond 2000: Science Education for the Future* (Millar & Osborne, 1998) initiated a debate that led to a range of innovations aimed at making the science curriculum fit for a broader purpose than had been the case until then. Developments started in England and Wales with the piloting of an optional course, *Science for Public Understanding* aimed at 17-18 year olds. Subsequently, the University of York and the Nuffield Curriculum

Centre developed a course for 14-16 year olds, *Twenty First Century Science*

Twenty First Century Science consists of three components – a core curriculum that explores both the major explanatory themes of science and a set of 'ideas-about-science' that all students study. These components are then followed by an additional course of academic science which is for those who wish to pursue the study of science at a later stage. Alternatively, students with a more vocational inclination can take a course in Applied Science.

The authors of *Twenty First Century Science* state that they would expect a scientifically literate person to be able to:

- appreciate and understand the impact of science and technology on everyday life;
- take informed personal decisions about things that involve science, such as health, diet, use of energy resources;
- read and understand the essential points of media reports about matters that involve science;
- reflect critically on the information included in, and (often more important) omitted from, such reports; and
- take part confidently in discussions with others about issues involving science. (*Twenty First Century Science*, 2008)

This conceptualisation of what it means to be scientifically literate reads almost as a meta-level set of aims. Underpinning these outcomes (what one might term separate 'literacies') are two different features: knowledge of how science works and knowledge of science explanations. In terms of the former, students need to "be able to reflect on scientific knowledge itself, including":

- the practices that have produced it;
- the kinds of reasoning that are used in developing a scientific argument; and
- the issues that arise when scientific knowledge is put to practical use.

In terms of knowledge of science explanations:

> No one can be said to be 'scientifically literate' unless they understand some science. But what matters is to have a broad understanding of the main scientific explanations that give us a framework for making sense of the world around us. (*Twenty First Century Science*, 2008)

The main scientific explanations in the scheme include: Chemical change; The interdependence of living things; The gene theory of inheritance; The theory of evolution by natural selection; Energy sources and use; Radiation; The Universe (*Twenty First Century Science*, 2008).

Approximately 10% of the project budget was set aside for an evaluation of the pilot. Three separate studies were commissioned into separate outcomes: knowledge and understanding; attitudes to science, and changes in classroom practice. One of the evaluation team, summarising the findings of the three studies, commented that:

> A clear majority of teachers indicated that they enjoyed teaching Core Science more than other courses. Given that nearly three-quarters also found it more demanding to teach, this clearly represents a major achievement (Burden et al., 2007, p. 25).

The rather cautious summing up continued thus:

> Perhaps the single most positive feature in the findings of these studies is that the project has succeeded in persuading a majority of the pilot teachers that it is more professionally rewarding than standard Double Award science. It has thus, in my view, engaged to a measurable degree with the desire of science teachers to offer a curriculum, particularly at Key Stage 4, which is livelier and more engaging than what has traditionally been available. Moreover it cannot be assumed that the teachers involved are all volunteers, or sympathetic to the aims of the project. This achievement also needs to be set against the well-established view that producing educational change of any kind is difficult: the institutional, professional and political barriers are large. All this is a significant achievement (Burden et al., 2007, p. 29).

The arrival of *Twenty First Century Science* was not greeted with universal acclaim as was indicated by the "being more 'fit for the pub' than the school room" quote mentioned above.

Netherlands – General Natural Sciences and the Junior College Utrecht

Innovative approaches have been tried in other parts of Europe. The Dutch minister of education set up an advisory committee in 1994 which proposed the introduction of an entirely new subject in the upper secondary curriculum of all students:

> The new subject, called *Algemene Natuurwetenschappen* ('General Natural Sciences'), or ANW, was to occupy well over 10% of the available time in Grade 10 [ages 16-17]. Its introduction, alongside the traditional science subjects that are optional in Grade 10, was part of a far-reaching innovation in upper secondary education (De Vos & Reiding, 1999, p. 711).

Osborne and Dillon (2008, p. 21) report that "the course has been contentious and gone through some transformation" since its introduction. De Vos and Reiding (1999), the course evaluators, noted that it was "extremely difficult" for teachers "to escape from the shadows of the science teaching tradition" (p. 718). They reported that even after the introduction of the course, science teachers' pedagogy was still dominated by a focus on content rather than developing an understanding of science (see, also, Bartholomew, Osborne & Ratcliffe, 2004). As Osborne and Dillon (2008) point out that "the teaching of science is an established cultural practice passed on from one science teacher to another" (p. 22) and it is difficult to change that culture quickly or easily.

Another Dutch initiative which has been piloted recently was aimed at more able students who can become de-motivated at school. Junior College Utrecht is a specialized science-enriched secondary school (van der Valk & Eijkelhof, 2007):

> Entrance to this school is competitive and seen as high-status. Students are taught at an accelerated pace with students left to learn minor material independently. In addition, there is a greater research focus and a significantly enhanced curriculum in which university specialists teach specific modules. Students reported that they enjoyed the challenge, the enriched elements and working with their intellectual equals. Such a mechanism – essentially one of making the study of science a high status subject – is one means of attracting more able students (Osborne & Dillon, 2008, p. 22).

Both these Dutch initiatives aim to address the issue of differentiating the curriculum offer so that students who want to continue into a science and/or technology career can be satisfied while, at the same time, the majority of students learn something potentially more relevant (though see Chapter 1 of Roth & Barton (2004) for a critical analysis of the relevance of contemporary science education).

Turkey: A new science and technology curriculum

Turkey initiated a major primary school curriculum reform in 2003. Science was one of five subjects chosen for reform and a new curriculum for grades 1-8 has been implemented. Koc Isiksal and Bulut (2007), commenting on the rationale for the curriculum reform note that:

> One of the major motivations for this curriculum improvement is to reach ideal international standards of education implemented in Europe, North America and East Asia. For instance, the new curriculum aims at creating learning environments, where students can share their ideas and actively participate, relating various disciplines to each other, and using different teaching methods within the enriched environment (p. 31).

Science is compulsory in Turkey from grade 4 (ages 9-10) through to grade 8 (ages 13-14). The seven learning areas in the new science and technology curriculum are: Physical Processes; Life and Living Beings; Matter and Change; The Earth and the Universe; Science Process Skills (SPS); Science-Technology-Society-Environment (STSE), and, Attitudes and Values (AV) (Taşar & Atasoy, 2006, p. 4).

What is particularly interesting about this curriculum, is the predicted outcomes of the Science-Technology-Society-Environment learning area. For example, at the end of Grades 6-8, a student should understand:

> That many sources of knowledge are utilized in developing technological products such as imagination, creative thinking, culture and traditions, mathematical knowledge, knowledge obtained through science about how nature functions, as well as the human capabilities of realizing and from whatever source bringing together the knowledge, facts, and materials that initially seem to be unrelated in order to make a technological product (Taşar & Atasoy, 2006, p. 6).

Such an outcome would be unusual in a Western curriculum document. Indeed, at the beginning of this paper I noted the concern of members of the 2007 Linné Scientific Literacy Symposium: “There is little flavour in school science of the importance that creativity, ingenuity, intuition or persistence have played in the scientific enterprise” (Linder et al., 2007, p. 7). There is an irony here that 2009 is the ‘European Year of Creativity and Innovation’.

Equally unusual to a Western European eye is one of the outcomes of the Attitudes and Values learning area (‘Developing a life style’) for the same three grades:

> (Development of a life style through the control of the value system over a long period of time)
>
> - Continuously checks on her/himself and the environment
> - Continues the habits for a healthy life
> - Realizes that everything is for the service of love, peace, and happiness
> - Self-disciplined (Self-controlled, prompt, self-evaluating, sincere, consistent)
> - Takes safety measures for her/himself and the environment.
>
> (Taşar & Atasoy, 2006, p. 9)

Although Taşar and Atasoy do not specifically refer to scientific literacy in their description of the new science and technology curriculum, it would appear that the reforms, aimed at reaching the standards of more developed countries, could reasonably fall under the scientific literacy umbrella.

Cross European projects: Pollen and Sinus

Osborne and Dillon (2008) identify another focus of development in Europe, that is, projects that have attempted to develop a more inquiry-based approach to the teaching of science:

> Notable amongst these are Pollen (www.pollen-europa.net) which is aimed at primary teachers in twelve European countries with an emphasis on teaching through inquiry; and Sinus and Sinus-Transfer which provide secondary school teachers in Germany with tools to change their pedagogical approach to science teaching in secondary school. The focus of these projects has been primarily on pedagogy and not on transforming the content itself. Such inquiry-based approaches are seen as providing children with: opportunities to use and develop a wider range of skills such as working in groups; more extended opportunities to explore their written and oral expression; and more open-ended, problem-solving experiences all in the belief that it will enhance student motivation and attainment. Some evidence does exist that these have been effective and it is these projects which are central to the recent report calling for a transformation in the pedagogy of science teaching in Europe. (p. 22)

The document that the authors refer to in their final sentence is the Rocard Report which, as we have seen, sets out an authoritative case for scientific literacy and radical change and yet promotes projects, originating in France and Germany that, in reality, offer little that teachers in the UK or the USA would regard as novel approaches to teaching science. Sometimes, though, it is necessary for every culture to reinvent the wheel.

Looking Beyond Europe

Although the focus of this brief overview has been Europe, there are some interesting parallels with what has been happening in North America, Australasia and Africa. For example, in Canada, which has seen many initiatives aimed at promoting Science-Technology-Society (STS) education for many years, a nationwide framework (CMEC, 1997) led to a series of province-based science curriculum revisions. The framework is based on a premise of science for all and scientific literacy is defined as “an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving, and decision-making abilities, to become lifelong learners, and to maintain a sense of wonder about the world around them” (Council of Ministers of Education, Canada [CMEC], 1997, p. 4). The Canadian approach differs from that taken in England and Wales and in the Netherlands in that it is an attempt to add a dimension to the curriculum rather than to create a special course. However, the approach used is to mandate that students do particular units which focus on problem-solving and on making decisions.

The approach taken in Australia (see Goodrum et al. 2000; Rennie et al. 2001) and the USA could be seen as more of an infusion in which frameworks and standards are used to impact across the curriculum. Roberts comments that frameworks such as *NSES* and the Australian example “typically reflect elements of both Vision I and Vision II, just because they are broad, idealized, multi-purpose, and intended to be enabling and facilitating” (2007a, p. 770).

In terms of issues arising from the Australian and the Canadian experiences, Roberts reviews what happens “whenever curriculum arrangements do not mandate Vision II outcomes” (2007a, p. 771). Fensham (1998) describes three instances where scientists have defeated proposals to implement courses based on Vision II approaches to scientific literacy. Blades (1997) identifies a similar situation in Canada. Roberts notes that these cases illustrate “the retreat from Vision II to Vision I” which, he continues, “occurred as a result of power politics within curriculum committees” (Roberts, 2007a, p. 771). De Vos and Reiding (1999) describe how a retreat from a Vision II approach can actually take place during the implementation of a new curriculum.

Moving beyond the more economically-developed countries, in South Africa, the Department of Education science curriculum policy actively promotes scientific literacy. Specifically, it does this by expecting:

- the development and use of science process skills in a variety of settings;
- the development and application of scientific knowledge and understanding; and
- appreciation of the relationships and responsibilities between science, society and the environment. (Department of Education, Pretoria, 2002, p. 4)

The policy is unusual in that it aims to make the science curriculum “distinctively South African” (Department of Education, Pretoria, 2002, p. 10). Roberts notes that the policy is worthy of “special interest because it includes attention to relationships between science, on one hand, and traditional practices and technologies as these relate to traditional wisdom and knowledge systems, on the other” (2007a, p. 773). The policy explains the challenges that students face:

> One can assume that learners in the Natural Sciences Learning Area think in terms of more than one world-view. Several times a week they cross from the culture of home, over the border into the culture of science, and then back again. How does this fact influence their understanding of science and their progress in the Learning Area? Is it a hindrance to teaching or is it an opportunity for more meaningful learning and a curriculum which tries to understand both the culture of science and the cultures of home? (Department of Education, Pretoria, 2002, p. 12).

More details of the rationale for the curriculum and the impact of its implementation can be obtained from Ogunniyi (2007). The idea of indigenous science education has less resonance in Europe than it has in Canada, South Africa and Australasia. Perhaps as a consequence European science education policy makers and researchers have yet to critique the curriculum in terms of its cultural appropriateness to the same extent that has happened elsewhere.

The Dimensions of Scientific Literacy

McEneaney (2003) is correct to claim that ‘scientific literacy’ has a ‘worldwide cachet’. It has become a rallying cry for a range of diverse interest groups all wanting to influence what science is taught in schools. The call can be heard in many parts of the world from Australasia to the Americas, and from Asia to Africa and Europe. However, as soon as words turn into action, the philosophical chasm that exists between Vision I and Vision II becomes a barrier to the major shift required in the culture of science education.

In Europe there are signs that, as we move towards the second decade of the 21st century, science educators and policy makers are rising to the challenge to provide a more appropriate science education for its citizens. However, when one reads the Rocard Report, with its clichéd rationales and overbearing assumptions, one is left feeling that we have a long way to go. We have yet to address, adequately, what is the purpose of science education? And we are nowhere near addressing the issues raised by Roth and Barton (2004) about the value of contemporary science education. So we plod on, looking over our shoulder at the monolith that is the content of science as students of all ages desert the sinking ship that is science education as we know it now.

Rather than wring our hands at the inadequacies of the term 'scientific literacy' we have to accept that it will have some considerable currency for years to come. We have to find ways to work with the term and then find ways to disrupt the hegemony that it holds over curriculum reform and assessment regimes. One way to do that might be to focus on the different dimensions of scientific literacy as identified by authors such as Shen who conceptualised three distinct but not mutually exclusive, categories of scientific literacy: *practical*, *civic*, and *cultural*. Practical scientific literacy is the "possession of the kind of scientific knowledge that can be used to help solve practical problems" (Shen, 1975, p. 46). Civic scientific literacy refers to the level of scientific knowledge and understanding necessary for informed public debate and sound policy-making. Cultural scientific literacy "is motivated by a desire to know something about science as a major human achievement" (Shen, 1975, p. 49). By breaking down scientific literacy into bite-sized chunks – scientific literacies, we can begin to see a way to organize the curriculum to meet the needs of different students throughout their time in and out of school. In so doing, we might begin to address the philosophical tensions between Vision I and Vision II conceptions of scientific literacy rather than pretend that they do not really matter.

References

Bartholomew, J., Osborne, J., & Ratcliffe, M. (2004). Teaching students 'Ideas-About-Science': Five dimensions of effective practice. *Science Education*, *88*, 655–682.

BBC News (2006). *Q&A*: *Science GCSE controversy*. Retrieved 7 December 2008 from, http://news.bbc.co.uk/1/hi/education/6039950.stm

BBC News (2008). *Minister checks on science exams*. Retrieved 7 December 2008 from, http://news.bbc.co.uk/go/pr/fr/-/1/hi/education/7765769.stm

Blades, D. (1997). *Procedures of power and curriculum change: Foucault and the quest for possibilities in science education.* New York: Peter Lang.

Burden, J., Campbell, P., Hunt, A., Millar, R., Scott, P., Ametller, J., Hall, K., Leach, J., Lewis, J., Ryder, J., Bennett, J., Hogart, S., Ratcliffe, M., Hanley, P., Osborne, J., & Donnelly, J. 2007). *Twenty First Century Science Pilot Evaluation Report*. York/London: UYSEF/Nuffield Foundation. Retrieved 7 December 2008 from, http://www.21stcenturyscience.org/data/files/c21-evaln-rpt-feb07-10101.pdf.

Council of Ministers of Education, Canada (CMEC). (1997). *Common framework of science learning outcomes K to 12: Pan-Canadian protocol for collaboration on school curriculum for use by curriculum developers.* Toronto, ON, Canada: Author.

Champagne, A.B., & Lovitts, B.E. (1989). Scientific literacy: A concept in search of definition. In A.B. Champagne, B.E. Lovitts & B.J. Callinger (Eds.), *This year in school science*: *Scientific literacy* (pp. 1–14). Washington, DC: AAAS.

Department of Education, Pretoria. (2002). *Revised national curriculum statement for grades R-9 (schools): Natural sciences.* Pretoria; South Africa.

De Vos, W., & Reiding, J. (1999). Public understanding of science as a separate subject in secondary schools in the Netherlands. *International Journal of Science Education*, *21*, 711–719.

Fensham, P. J. (1998). The politics of legitimating and marginalizing companion meanings: Three Australian case stories. In D.A. Roberts & L. Östman (Eds.), *Problems of meaning in science curriculum* (pp. 178–192). New York: Teachers College Press.

Goodrum, D., Hackling, M., & Rennie, L. (2000). *The status and quality of teaching and learning of science in Australian schools: A research report.* Canberra: Department of Education, Training and Youth Affairs.

High Level Group on Science Education. (2007). *Science Now: A renewed pedagogy for the future of Europe.* Brussels: European Union.

Hodson, D. (2008). *Towards scientific literacy. A teachers' guide to the history, philosophy and sociology of science*. Rotterdam: Sense.

Koc, Y., Isiksal, M., & Bulut, S. (2007). Elementary school curriculum reform in Turkey. *International Education Journal*, *8*(1), 30–39.

Laugksch, R.C. (2000). Scientific literacy: A conceptual overview. *Science Education, 84*(1), 71–94.

Lee, O. (1998). Guest Editorial: Scientific literacy for all: What is it, and how can we achieve it? *Journal of Research in Science Teaching*, *34*(3), 219–222.

McEneaney, E.H. (2003). The worldwide cachet of scientific literacy. *Comparative Education Review, 47(2)*, 217–237.

Members of the Linné Scientific Literacy Symposium (2007). Statement of Concern. In C. Linder, L. Östman, & P.-O. Wickman (Eds.), *Promoting scientific literacy: Science education research in transaction* (pp. 7–8). Uppsala: Uppsala University.

Millar, R., & Osborne, J. (Eds.). (1998). *Beyond 2000: Science education for the future*. King's College, School of Education.

Ogunniyi, M.B. (2007). Teachers' stances and practical arguments regarding a science-indigenous knowledge curriculum: Part 2. *International Journal of Science Education*, *29*(10), 1189–1207.

Organisation for Economic Cooperation and Development. (2007). *Executive Summary PISA 2006: Science competencies for tomorrow's world*. Paris: OECD.

Osborne, J., & Dillon, J. (2008). *Science education in Europe: Critical reflections*. London: The Nuffield Foundation.

Rennie, L., Goodrum, D., & Hackling, M. (2001). Science teaching and learning in Australian schools: Results of a national study. *Research in Science Education, 31*, 455–498.

Roberts, D.A. (2007a). Scientific literacy/Science literacy. In S.K. Abell & N.G. Lederman, (Eds.), *Handbook of research on science education* (pp. 729–780). Mahwah, NJ: Lawrence Erlbaum.

Roberts, D.A. (2007b). Opening remarks. In C. Linder, L. Östman, & P.-O. Wickman, (Eds.), Promoting scientific literacy: Science education research in transaction. *Proceedings of the Linnaeus Tercentenary Symposium* (pp. 9–17). Uppsala: Uppsala University.

Roth, W.-M., & Barton, A.C. (2004). *Rethinking scientific literacy.* New York, NY: RoutledgeFalmer.

Royal Society. (1985). *The public understanding of science*. London: Royal Society.

Shamos, M. H. (1995). *The myth of scientific literacy*. New Brunswick, NJ: Rutgers University Press.

Shen, B.S.P. (1975a). Scientific literacy and the public understanding of science. In S. B. Day (Eds.), *Communication of scientific information* (pp. 44–52). Basel: Karger.

Shortland, M. (1988). Advocating science: Literacy and public understanding. *Impact of Science on Society, 38*(4), 305–316.

Snow, C.P. (1962). *The two cultures and the scientific revolution*. Cambridge, UK: Cambridge University Press.

Stables, A. (1996). Paradox in compound educational policy slogans: Evaluating equal opportunities in subject choice. *British Journal of Educational Studies*, *44*(2), 159–167.

Taşar, M.F., & Atasoy, B. (2006, November). *Turkish educational system and the recent reform efforts: The example of the new science and technology curriculum for grade 4–8.* Paper presented at the meeting of Asia Pacific Educational Research Association, Tai Po, New Territories, Hong Kong.

Twenty First Century Science (2008). Retrieved 7 December 2008 from,

http://www.21stcenturyscience.org/
van der Valk, T., & Eijkelhof, H. (2007). Junior College Utrecht: Challenging motivated upper secondary science students. *School Science Review*, 88, 63–71.
Waterman, A.T. (1960). National Science Foundation: A ten-year résumé. *Science*, *131*(3410), 1341–1354.

Author

Justin Dillon is Senior Lecturer in Science and Environmental Education and Head of the Science and Technology Education Group at King's College London, UK. He is President of the European Science Education Research Association. **Correspondence:** Department of Education and Professional Studies, King's College London, Franklin-Wilkins Building, 150 Stamford Street, London SE1 9NH, UK. E-mail: justin.dillon@kcl.ac.uk.