WHAT IS SCIENTIFIC LITERACY AND WHY DO WE NEED IT?

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The history of science education is easily traced through the slogans, catchphrases and rallying calls that have come and gone: “Children as scientists”, “Process, not product”, “Science for all”, “Children making sense of the world”, and so on. In recent years, the call for increased levels of scientific literacy has assumed centre-stage in science education rhetoric in several parts of the world and organizations such as the American Association for the Advancement of Science (AAAS, 1989, 1993), the Council of Ministers of Education, Canada (CMEC, 1997) and UNESCO (1993) have used it to frame major efforts to reform the science curriculum. Its prominence in the contemporary science education literature prompts the two questions in my title.

What Is Scientific Literacy?

The term scientific literacy first appeared in the US educational literature in papers by Paul Hurd (1958) and Richard McCurdy (1958). It was enthusiastically taken up by others as a useful rallying call, but had little in the way of precise or agreed meaning until Pella, O’Hearn, & Gale (1966) suggested that it comprises an understanding of the basic concepts of science, the nature of science, the ethics that control scientists in their work, and the interrelationships of science, technology and society. Almost a quarter century later, Science for All Americans (AAAS 1989, p.4) drew upon very similar categories to define a scientifically literate person as “one who is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes.” To suggest that debate had been stagnant between 1966 and 1989 would be to seriously misinterpret matters. Indeed, following the work of Milton Pella and his co-workers, there was a period of intense debate, definition and counter-definition, culminating in Gabel’s (1976) detailed analysis of the literature in terms of eight dimensions (organization of knowledge; intellectual processes; values and ethics; process and inquiry; human endeavour; interaction of science and technology;
interaction of science and society; interaction of science, technology and society) and nine categories of educational objectives (Bloom’s six categories of cognitive objectives plus three affective objectives – valuing, behaving and advocating). As Roberts (1983) comments, “What is immediately striking about Gabel’s model is that it includes, under the definition of scientific literacy, every category of science education objectives . . . it now means virtually everything to do with science education” (p. 22). In more recent times, the Royal Society’s (1985) assertion that scientific literacy “can be a major element in promoting national prosperity, in raising the quality of public and private decision making and in enriching the life of the individual” (p. 9) underlines the key distinction between those who see scientific literacy as the knowledge, skills and attitudes deemed essential to a career as a professional scientist, engineer or technician, and those who see it as the capacity to access, read and understand material with a scientific and/or technological dimension, make a careful appraisal of it, and use that evaluation to inform everyday decisions, including those made at the ballot box.

According to Klopfer (1969), this distinction should be reflected in a differentiated school science curriculum: “One curricular stream…designed for students planning to enter careers as scientists, physicians, and engineers…the other…designed for students who will become the nonscientist citizenry . . . housewives, service workers, salesmen etc. . . . Differentiation of students (should) begin at about age fourteen when they choose the high school they will attend” (p. 203). As a variant of this position, the authors of Beyond 2000: Science Education for the Future (Millar & Osborne, 1998) state that the science curriculum from age five to sixteen (the years of compulsory schooling in the UK) should be a course to enhance general scientific literacy, with more specialized science education delayed to later years: “the structure of the science curriculum needs to differentiate more explicitly between those elements designed to enhance ‘scientific literacy’, and those designed as the early stages of a specialist training in science, so that the requirement for the latter does not come to distort the former” (p. 10).

Considerations such as these prompt the second question: Why do we need scientific literacy?

Why Do We Need Scientific Literacy?

Reviewing what they describe as an extensive and diverse literature, Thomas and Durant (1987) identify a range of arguments for promoting scientific literacy. Among the perceived benefits to society as a whole, they identify the familiar economic argument (to which I return below), enrichment of the cultural health of the nation and intellectual life in general, and enhancement of democracy. On the latter score, they note that increased scientific literacy “may be thought to promote more democratic decision-making by encouraging people to exercise their democratic rights), which may be regarded as good in and of itself; but in addition, it may be thought to promote more effective decision-making (by
encouraging people to exercise their democratic right wisely” (pp. 5-6). In my view, whether wise decision-making is the likely outcome of enhanced scientific literacy in the wider community depends crucially on how scientific literacy is defined and how it is translated into curriculum practice. Thomas and Durant identify several strands of argument that increased scientific literacy would be of major benefit to science itself, including increased numbers of ‘recruits’, greater support for scientific research and more realistic public expectations of science. Shortland (1988), for example, states that confidence in scientists and public support for science depends on “at least a minimum level of general knowledge about what scientists do” (p. 307). More significantly, support depends on whether the public values what scientists do. Of course, it is naïve to assume that enhanced scientific literacy will inevitably translate into simple trust of scientists and unqualified support for the work they choose to do. A scientifically literate population, with a rational view of the world, a predisposition to think critically and the capacity to appraise scientific evidence, is much more likely to challenge the priorities of scientific research and the direction of technological innovation (Hodson, 1994).

Arguments that scientific literacy confers individual benefits come in a variety of guises. For example, it is widely argued that scientifically literate individuals have access to a wide range of employment opportunities and are better prepared to respond to the introduction of new technologies. Moreover, they are better able to cope with the demands of everyday life in an increasingly technology-dominated society, better positioned to evaluate and respond appropriately to scientific and pseudoscientific arguments used by advertisers, commercial organizations and politicians, and better equipped to make important decisions that affect their health, security and economic well-being.

In recent years, the economic argument has become dominant, especially in North America. It is both powerful and persuasive, and it carries a substantial sub-text intended to create a particular view of the world. Its power is located in the way it influences how we think about society and our relations with others, and the consequent impact on how we act in the world. When school confronts students, almost daily, with a language that promotes economic globalization, increasing production and unlimited expansion, it is implicated in the manufacture and maintenance of what Bowers (1996, 1999) calls the myths of modernity. Some would claim that the resulting mind-set puts at risk the freedoms of individuals, the spiritual well-being of particular societies, and the very future of the planet. In Edmund O’Sullivan’s (1999, p.27) words:

Our present educational institutions which are in line with and feeding into industrialism, nationalism, competitive transnationalism, individualism, and patriarchy must be fundamentally put into question. All of these elements together
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coaalesce into a world view that exacerbates the crisis we are now facing.

What is abundantly clear is that little of the world’s poverty, injustice, terrorism and war will be eliminated, and few of the world’s environmental crises (ozone depletion; global warming; land, air and water pollution; deforestation; desertification; and so on) will be solved, without a major shift in the practices of western industrialized society and the values that sustain them. Interestingly, one of the keys to ameliorating the current situation may lie in increased levels of scientific literacy among the world’s citizens – an idea explored a little in the following section and at length in Hodson (2003).

What Can We Conclude?

Where does all this propaganda for scientific literacy leave us? It seems that the case for greater scientific literacy, and the kind of curriculum proposals that would follow from it, change with social context. They are a product of their time and place: they do not easily cross national or cultural boundaries (Tippens, Nichols, & Bryan, 2000) and do not transfer comfortably from one era to another. We should also note that as science itself changes, so our view about what counts as legitimate scientific literacy also changes. The kind of science currently studied in conventional science curricula (the work of Newton, Darwin and Dalton, for example) bears very little resemblance to the kind of research carried out in the laboratories of the early 21st century, and the values that underpin this research are very far removed from the traditional portrayal of science as the disinterested pursuit of objective truth. Given the increasing industrialization and militarization of the scientific enterprise, claims for the cultural and ethical value of scientific literacy seem hopelessly misplaced, if not downright dishonest. At the same time, claims that scientific literacy builds economic prosperity have become more believable – to some – as they have become more stridently promoted.

Are there any elements of scientific literacy that are valid in all contexts and for all time? Is there a conception of scientific literacy that can re-direct science and technology along more socially just, environmentally responsible and ethically sound lines? Yes, if scientific literacy means knowing what scientific resources to draw on, where to find them and how to use them (Fourez, 1997). Yes, if the real function of scientific literacy is to help people learn to think for themselves and to reach their own conclusions about a range of issues that have a scientific and/or technological dimension. Yes, if scientific literacy is sought not because it improves the economy, produces more technological ‘goodies’ or provides job opportunities for individuals, but because it liberates the mind. Yes, if it enables us to decide which experts to trust and which conclusions to rely on.
We are increasingly dependent on scientists and the inquiries they conduct to tell us about the safety hazards associated with various products and procedures, the toxic effects of pesticides, pharmaceuticals and other materials we encounter in everyday life, the threats to our health posed by the proximity of toxic waste dumps, nuclear power plants and overhead power lines, and the large scale compromising of environmental health through loss of biodiversity, increasing desertification, pollution and global warming. It is crucial, therefore, that each of us understands how reliable and valid data are collected and interpreted. It is crucial, too, that we understand the ways in which contextual interests can and do shape the inquiry and its interpretation and reporting. Without this insight, we have no alternative but to take reports that blame or exonerate at face value.

What I am arguing here is that scientific literacy for active citizenship, responsible environmental behaviour and social reconstruction lies more in learning about science than it does in learning science. No science curriculum can equip citizens with thorough first-hand knowledge of all the science underlying all important issues, but it can enable them to understand the significance of knowledge presented by others and it can enable them to evaluate the validity and reliability of that knowledge and to understand why scientists often disagree among themselves on major matters such as global warming, without taking it as evidence of bias or incompetence. It is not my intent to argue that knowledge of the major concepts, ideas and theories of science is unimportant; indeed, it would be a very curious state of affairs indeed to claim scientific literacy and admit to knowing no science at all. Nevertheless, my contention is that we should place considerably more emphasis on those elements of the history, philosophy and sociology of science that would enable students to leave school with a robust knowledge about the nature of scientific inquiry and theory building, an understanding of the role and status of scientific knowledge, an ability to understand and to use the language of science, some insight into the sociocultural, economic and political factors that impact the priorities and conduct of science, and some experience of conducting authentic scientific investigations.

References


