Scientific Literacy: Who Needs it in a 'Black Box' Technological Society?

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Abstract

This paper will question the widely accepted position that there is a need for widespread, scientific literacy that spans a broad range of topics if that literacy lacks the conceptual depth, and/or intellectual rigor, to provide any basis for rational, scientifically informed, choices. The paper will present an argument that, in fact, it would be more effective if functional, widespread, scientific literacy were only taught in Key Stage 3 (age 11–14)where it would focus almost exclusively and in greater depth on those areas of science relating to human health with some basic chemistry and physics – the biggest of the 'big ideas'. With science in Key Stage 4 (age 15-16) reverting back to a more traditional 'science for the future scientist' and that studying biology, chemistry and physics at Key Stage 4 would become an option rather than a core requirement. We will also argue that, in a 'black box' technological world, individuals can be, and indeed are, very effective users of technology, and the underlying science, without the need for them to be scientifically literate.

Keywords: *Scientific literacy, black box;*

Introduction

Other than the occasional dissenting voice [1] there is a shared belief within the scientific and science education communities [2] of the need for wide-spread scientific literacy. This article argues that widespread, functional, scientific literacy, that would enable the average individual who ceases to study science at age 16 to make rational, scientifically based, choices about a *broad* range of socio-scientific issues, is both unrealistic and unachievable.

This does not mean ceasing to teach scientific literacy but rather recognising the need for a more tightly focused form of scientific literacy. This would enable individuals to make rational, scientifically based, choices but *only* in a *narrow* range of socio-scientific issues. These issues would focus primarily on human biology, along with some aspects of chemistry and physics – the biggest of the 'big ideas' [3], all of which could be taught by the end of KS3 (age 11-14). With the teaching of tightly focused scientific literacy completed by the age of 14, biology, chemistry and physics would, like history and geography in England, become optional subjects. This would enable the teaching of science to refocus towards science content – a move away from what Sir Richard Sykes, Rector of Imperial College London, stated [4] as being a "dumbed down syllabus" towards educating students wanting to pursue a science subject post-compulsion i.e. science for future scientists.

This article suggests that a feature of living in a scientifically advanced society is that we cannot have a sufficient depth of knowledge, across all topics, to be able to make rational, scientifically, informed decisions and so must rely on experts. Indeed, in our view, an individual's ability to use technology effectively does not depend upon their being scientifically literate – mobile phones, USB sticks, and in-car satellite navigation systems – can all be used *without* any scientific understanding of how or why they work.

Five arguements have been provided [2] as to why people should know something of science and we will consider the evidence for and against each in turn.

The economic argument

Whilst science-based industries need highly qualified scientists, by which we mean those leaving university with degrees in science subjects, they have little need for students leaving school with a benchmark GCSE qualification in science at 16. Yet even here the economic argument overlooks basic principles of supply and demand [1] that would suggest that if practising scientists (as against science graduates working in corporate finance) play a vital role in the economic prosperity of the

nation – then their salaries should rise to attract and retain them. Indeed, despite claiming to need ever more scientists 74% of those who graduate in the US with a major degree in science, technology, engineering and maths find employment outside of these areas [5] with similar findings [6] in the UK.
What is also still missing from the economic argument is research-based evidence that GCSE science provides industry with employees with essential levels of *useable* scientific knowledge and skills without which those industries would be unable to function. Science-based industries would not function without science graduates but would they also not function if, for example, their reception clerk did not have a GCSE in a science subject? Whilst having GCSEs in science can sometimes enhance individual earning potential this can owe more to the fact that having science GCSEs are placed as a requirement for certain careers, such as primary teaching, and again research is needed to ascertain the extent to which those working in such careers use their GCSE knowledge and/or skills. Primary teachers still teach history and geography to their pupils without having to have a GCSE in those subjects themselves.

The democratic argument

This argument suggests that science knowledge enables individuals living in a scientific society to engage in debate and decision-making in contexts that involve scientific information. For example, it could be argued that individuals considering whether to build a local wind farm close to their home would benefit from an understanding of the nature of global warming, the pay-back time to off-set the embedded carbon dioxide in the concrete turbine towers (and any access roads), dangers to wildlife, the viability of carbon capture for fossil fuel power station alternatives and for the safe storage of nuclear waste – including an understanding of half life – for nuclear power station alternatives.
However, this argument fails to consider the level of scientific conceptual understanding that is required to make scientifically rational informed decisions. The fact that highly qualified scientists can disagree on, for example, the dangers associated with the use of nuclear power raises the question as to what can realistically be expected of students, with very basic scientific GCSE content knowledge, in terms of this and other arguments. Indeed, if we rely on a doctor for a medical diagnosis, or a pilot to fly us around the world, is there any reason not to rely on nuclear physicists to guide/advise us about the safety of nuclear power stations?
Furthermore, there remains little objective evidence as to the extent to which individuals, even those with a high level of science education, make decisions based on their scientific knowledge. People are more often influenced in their decision making by their personal beliefs and values [7] and, for example, with regards the construction of wind farms 'NIMBYism' (an acronym for the phrase "Not In My Back Yard) and, in particular the impact on local house prices and vistas, probably plays a much larger role in an individual's decision making process than an understanding of global warming.

The utility argument

This argument suggests – again there is a lack of research evidence about the level that this needs to be at – that science knowledge is of value to individuals living in a society dependent on science. From this perspective it is important to teach science in order for students to develop the knowledge they will subsequently utilise in decision making about science related issues at an individual level (for example, nutrition, health and safety) thereby enabling them to make rational, scientifically, informed choices as consumers [8].
However, consumer choices often appear to be based on a host of different factors, other than scientific knowledge, and the need for scientific knowledge in everyday life situations seems to be overly exaggerated. There is no evidence that physicists, for example, have fewer car accidents because they understand mechanics better than non-scientifically literate people. Indeed, despite science being a core subject in England we have an increasing rate of childhood obesity and type 2 diabetes which shows that the dietary choices made by those children, and their parents - who also probably had a core science education up to the age of 16 - are more likely based on convenience and cost rather than scientific knowledge.

The social argument

This argument points to the need to link science, and scientific research, and the wider non-scientific society. It has been argued [2] that the increasing specialisation and remoteness of much scientific knowledge has created a gap between society at large and science, which threatens both. It can be argued that a scientifically educated individual – it is unclear what level of science education is required – would feel less alienated from science and scientific research, and perhaps better sympathise with the aims of science. Of course this leaves unanswered, and un-researched, the question of whether individuals who might be considered as being scientifically illiterate actually do feel alienated from science or whether that alienation is, erroneously, attributed to them by scientists who are unable to accept that some people are very content to simply use the products that science provides and rely on experts. Do passengers who fly on jet planes actually feel alienated from science because they lack an understanding of Bernoulli's principle, or Newton's third law, or is it the case that they just get on the plane and the question of how hundreds of tons of metal not only stays up in the air, but also moves very rapidly through it, either does not even occur to them or, if it does, the answers are simply of no interest to them?

The cultural argument

If science is one of the defining cultural products that characterise our society then part of the role of education is to transmit that cultural heritage to successive generations. Whilst we see this as the strongest of the five arguments for the teaching of science to *all* students, we question whether, and on what basis, science is any more important in terms of cultural heritage than history, music or art: none of which are compulsory subjects in Key Stage 4 (age 15-16). Furthermore, we might reasonably ask to what extent does the teaching of school science inculcate an awareness and appreciation of the contribution made by science to our cultural heritage and might such an awareness and appreciation be better taught in history?

Conclusion

The reality of the complex society in which we live is such that we depend on experts and professionals. Most of us are not scientists or designers of technology and yet irrespective of our academic achievements are all able to use mobile phones, send e-mails and fly around the world without needing to know, or in many cases having any desire to know, anything about the underlying science that enables such technology to function. Whilst there is undeniably a need for a level of functional scientific literacy in our society this should essentially be focused onto those areas of science that relate to human health and some basic chemistry and physics – all of which could be effectively taught by the end of Key Stage 3 (age 14). Beyond this point we argue that there ought to be three, optional, academic subjects: biology, chemistry and physics that are taught to those who *want* to study these subjects and a general science that would be an option for those who might require some basic level science in a future job and/or apprenticeship.

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