What place does science have in an aims-based curriculum?

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ABSTRACT This article argues that school curriculum development should start with aims rather than with subjects and that the fundamental aims of school education should be to enable each learner to lead a personally flourishing life and to help others to do so too. These overarching aims give rise to more specific ones by considering how human flourishing requires such things as the acquisition of a broad background understanding, moral education, a life of imagination and reflection, and preparation for work. This approach would result in a school science education that had similarities with much current school education, which is desirable as it suggests that the approach is not completely unrealistic, but some non-trivial differences too, which is desirable as it suggests that the approach does not simply replicate existing approaches.

When I heard the learn'd astronomer,
When the proofs, the figures, were ranged in columns before me,
When I was shown the charts and diagrams, to add, divide, and measure them,
When I sitting heard the astronomer where he lectured with much applause in the lecture-room,
How soon unaccountable I became tired and sick,
Till rising and gliding out I wander'd off by myself,
In the mystical moist night-air, and from time to time,
Look'd up in perfect silence at the stars.
(Walt Whitman, 1819–1892)

There has been debate about the purpose of science education and what to include in the science curriculum since long before I started to teach science in schools over 30 years ago. Thankfully, many school students enjoy learning science and choose to continue to study one or more of its constituent subjects once they get the opportunity to make such choices. Nevertheless, as is well known, there is a general perception in many countries that it would be better if more young people continued with science than do so at present. Typically, the reason for this, at least as expressed by politicians and business people, is that the country needs scientists. Often the metaphor used is one of competition: that a country will slip down some global league table if it does not have more students studying STEM (science, technology, engineering and mathematics) subjects.

Recent research in the UK shows that the reasons why more students choose not to study science start early in life and are pretty firmly in place within the first year or two of secondary schooling (Archer *et al*., 2010; Mujtaba and Reiss, 2013). Young people generally hold that science is important, it is just that too often they feel it is not for them. The Walt Whitman poem above provides one reason for this: science can seem too reductionist and may miss the big picture. But there are other, less romantic reasons. Many students find school science quite hard and too often it seems to provide few opportunities for them to be creative and autonomous (Schreiner, 2006).

In this article, I want to start further back, to ask more fundamentally how we should construct a school curriculum and what the place of science should be within that curriculum.

Deciding what to put in a school curriculum

There are a number of ways in which curricula can be developed. National curricula typically start with a list of subjects: mathematics, the predominant language, science and so on. Aside from minor skirmishes (for example, over citizenship, theatre studies and dance), they take for granted a dozen or so discrete school subjects

and the knowledge they entail. There is a general implicit presumption that agreement exists as to the purpose of school education, without these purposes being spelt out and examined in any depth.

An alternative to starting with subjects is to start further back, with aims (Reiss and White, 2013). One reason for starting with aims is that if one doesn't, one finds that they end up getting tagged on. For example, when the National Curriculum for England and Wales was first created in 1988, it had next to no aims to guide it. More recent versions have included lists of overall aims, but these have been tacked on to a structure already in place. Crucially, they do not generate or inform that structure.

The aims of education

Education has had diverse aims over the years. As Harris has put it:

… in the very first lecture of every course I give, I stress that 'education' is a changing, contested and often highly personalised, historically and politically constructed concept. To illustrate this I read a few dictionary definitions of 'education', as well as a selected set of stated 'aims of education'. When students hear that D. H. Lawrence claimed education should aim to 'lead out the individual nature in every man and woman to its true fullness', that for Rousseau the aim of education was 'to come into accord with teaching of nature', that R. M. Hutchins saw the aim of education as 'cultivation of the intellect', that A. S. Neill believed the aim of education should be to 'make people happier, more secure, less neurotic, less prejudiced', and that John Locke claimed 'education must aim at virtue and teach man to deny his desires, inclinations and appetite, and follow as reason directs'; hopefully the penny has dropped. (Harris, 1999: 1)

Nevertheless, even within the examples that Harris cites, chosen to represent their diversity, we can see two broad groupings. First, there are those where the intention is to develop the individual for her/his own benefit, and second, those where the intention is to develop individuals so that they collectively contribute to making the world a better place. John White and I contend that there are two fundamental aims of school education, namely to enable each learner to lead a life that is personally flourishing and to help others to do so too.

What constitutes a flourishing life?

The idea that humans should lead flourishing lives is among the longest established of ethical principles, one that is emphasised by Aristotle in his *Nicomachean Ethics*. There are many analyses as to what precisely constitutes a flourishing life. A hedonist sees it in terms of maximising pleasurable feelings and minimising painful ones. Related to this, a person may wish to maximise their wealth, fame, consumption or, more generally, to satisfy their principal desires, whatever these may be. Admittedly, there are difficulties with all these accounts (White, 2011). A problem with desire-satisfaction is that it allows ways of life that virtually all of us would deny were flourishing, a life mainly devoted to drinking very large amounts of alcohol, for instance.

A life filled with wholehearted and successful involvement in more worthwhile pursuits – significant relationships, meaningful work and such things as gardening, cooking, watching excellent films and reading good books – is on a different plane. Virtually all of us would rate it fulfilling. At the same time, nearly all of us in a modern society such as ours presume it is largely up to us to choose the mix of relationships and activities that best suits us (certain family obligations are generally excepted from this generalisation, though fewer than in the past).

A central aim of the school should therefore be to prepare students for a life of autonomous, wholehearted and successful engagement in worthwhile relationships, activities and experiences. This aim also involves acquainting students with a wide range of possible options from which to choose. With their development towards autonomous adulthood in mind, schools should provide students with increasing opportunities to decide the pursuits that best suit them. Part of the function of schooling, and indeed parenting, is to prepare young people for the time when they will need to, and be able to, make decisions more independently.

Equipping every student to help others to lead personally fulfilling lives

We want people to want other people, as well as themselves, to lead fulfilling lives. Schools can reinforce and extend what parents and others in families do in developing consideration for others. Schools can widen students' moral sensitivity

beyond the domestic circle to those in other communities, locally, nationally and globally.

As part of their moral education, schools should help students to become informed and active citizens. This means encouraging their students to take an interest in political affairs, at local, national and global levels, from the standpoint of a concern for the general good. And they should do this with due regard to framework values such as freedom, individual autonomy, equal consideration and cooperation.

The great majority of students will contribute to the general wellbeing, as well as to their own, through work. This will often be remunerated, although it may not be, for example when caring for one's own children or elderly relatives. As autonomous beings, students will eventually have to make decisions about what kind of work to engage in. Schools should be helping them by making them aware of a wide range of possibilities and routes into them, as well as their advantages and disadvantages.

Broad background understanding

There is an important link between the two major aims. Whatever we do in our lives that brings us personal benefit or is intended to benefit others takes place against a broad background of thoughts about the world we live in. Closest to home are thoughts about what sort of beings we are. We all grow up to believe, for instance, that we will live at most for a century or so, that we may or may not stay healthy, and that the future has a considerable element of unpredictability. We all come to see our lives as inextricably bound up with the lives of other human beings. These perceptions alone cannot but influence the way we lead our lives.

Part of the task of education – at home and at school – is to help students to form this background that will colour everything they do. At a fundamental level, some will live by religious or other beliefs that give us answers to the deep questions, while others will live without such beliefs. But much of the background is less contested. Indeed, much of it will consist of well-founded scientific conclusions – about, for instance, the social nature of human beings and our part in the ecology of nature. This leads into the second part of this article, where I explore what an aims-based approach to curriculum design might mean for education about the sciences in school. I begin by reviewing current aims for school science education.

Current aims for school science education

There are a number of aims for school science education (Reiss, 2007), although these are often implicit. A frequent aim of many science courses has been for them to provide a preparatory education for the small proportion of individuals who will become scientists (in the commonly understood sense as employed professionals). This aim, although important economically and therefore supported by industry and successive governments, has been critiqued on democratic grounds (e.g. Millar and Osborne, 1998). After all, what of the great majority of school students who will not become such scientists?

Another aim is to enable 'scientific literacy'. Although there has been a long-running debate as to the meaning of the term (e.g. Miller, 1983), generally scientific literacy is seen as a vehicle to help tomorrow's adults understand scientific issues. The basic notion is that science education should aim to enhance understanding of key ideas about the nature and practice of science, as well as some of the central conclusions reached by science. A fuller definition is provided by PISA:

> *... an individual's scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science-related issues, understanding of the characteristic features of science as a form of human knowledge and enquiry, awareness of how science and technology shape our material, intellectual, and cultural environments, and willingness to engage in science-related issues, and with the issues of science, as a reflective citizen.* (OECD, 2009: 14)

A further aim of many science courses is that students, both now and as adults, will be able to benefit materially from the science they have learnt. At its most straightforward, this might be by entering paid employment that draws on what they have learnt in science. Although, as noted above, most students do not enter such careers, they too may still benefit individually from their school science. For example, in most science courses, in countries round the world, it has long been accepted that one of the justifications for the inclusion of certain topics is that knowledge and understanding of them can promote human health.

Another, more mundane, way in which school science might help individual advancement is by

providing what might be called 'science education for consumerism'. This is the hope that school science education might, for example, help us choose the most appropriate technological goods (for example, is it worth buying a hybrid car rather than one that runs on diesel or petrol only?). This is a subset of the more general argument that science education should be for public understanding (Millar, 1996), itself closely related to education for scientific literacy.

A further aim of school science education is that it should enhance social justice or result in socio-political action. For example, Calabrese Barton has shown that active participation in science lessons, and real learning about science, take place when students believe that their work can bring about improvements for themselves, their friends and their families (Calabrese Barton, 2001). She shows that many of the students with whom she and her colleagues worked, while seen in school science as low achievers, were actually perfectly capable of high-quality science work provided they were given real choice in the science they worked at.

It is evident that there is currently a diversity of aims for school science education. It is important, though, to emphasise that most teaching of school science proceeds on the assumption that such knowledge is good for students, without the precise aims having been thought through with any rigour and without the science curriculum beginning from such aims. Instead, science curricula generally begin with science. It might be thought that this is a sensible starting point, but it leads all too often to disengagement as many students fail to understand the point of what they are learning. In the next and final section I outline how an aims-based approach to the curriculum might inform science education.

An aims-based approach to education about the sciences in school

School science, worldwide, is privileged in the curriculum. So far as I am aware, the school curricula of all countries have science as a core requirement to be taught, typically, from the start of schooling (e.g. 5, 6 or 7 years of age) up to the end of compulsory schooling (e.g. 15 or 16 years of age). While what precisely is included within 'science' varies a bit from country to country, and while it is not always called 'science' for younger pupils, the presence of school science is nearly always accepted as a given. Furthermore, what is included within the school science curriculum is typically determined mainly by curriculum history – that is, what has previously been included – and by occasional battles; for instance, in England and Wales, about the extent to which the earth sciences should be included within science, within geography or omitted from the school curriculum.

The argument for an aims-based curriculum is that school education should equip every student:

- to lead a life that is personally flourishing;
- to help others to do so too.

As discussed above, for these two aims to be realised, a third is added, the area of 'background understanding' – the understanding of human nature, of our social life and how it has developed as it is, and of the natural world in which we live. It is partly in its contribution to our background understanding that science begins to assert its case for inclusion in the school curriculum.

Our own society, unlike most in the past, is powerfully shaped by science. As a result, much of our background consists of presumptions about which there is little or no reasonable doubt: for instance, the belief that the Earth goes round the Sun rather than vice versa, and that germs that can cause illness come from pre-existing germs rather than from 'bad air' (malaria) or elsewhere.

More fundamentally, students need to be helped to understand their own nature and that of other people as human beings. This has a biological aspect: they should understand something of how they function biologically and also how they are connected with the rest of the living world. Some grasp of evolutionary theory, genetics and child development is essential here. But there is also a cultural aspect: human beings, as language users, are the only animals (setting aside the beginnings of self-consciousness seen in a few other species, such as the other great apes) known to be conscious of their own existence. Students need to be inducted into the implications of this for our social life, including its forms of cooperation and its intellectual and artistic achievements.

As far as the sciences go, perhaps above all they help us to situate ourselves both temporally and spatially in the world in which we live. It is clear that the universe is almost unimaginably old – some 13.7 billion years is the current consensus

– and that there are literally many billions of stars, a high proportion of them with planets of their own. In one sense then science tells us that our own world is not that special. And yet we still do not know whether our planet alone is home to life.

Science proceeds through the objective testing of hypotheses about our material world. The growth in scientific knowledge gives us greater understanding of that world. Thanks to science, there is, for instance, no need for people to be superstitious or to fear witchcraft. Natural disasters are not the result of individual wickedness.

School coverage of the sciences should therefore include something about what is generally referred to as 'the nature of science', that is, how scientific knowledge is arrived at and its limits (Kind and Kind, 2008; Williams, 2011). For example, science tells us much about why the world is as it is, but not what we should do in it. If we want students to know something of the ethical implications of science, we either have to admit the teaching of ethics within science or arrange for such teaching to occur elsewhere in the curriculum.

However, when deciding what material should be included within a curriculum, the criterion of background understanding is not enough. As argued above, the great majority of students will contribute to the general wellbeing, as well as to their own, through work. While mathematics and technology have been around for millennia and 'modern' science for at least several hundred years, it is clear that the proportion of jobs that rely on these subjects has increased in recent decades.

How, though, should one decide, for such possible employment purposes, how much and what sort of science students should experience when at school? The first principle, surely, should be to provide sufficient material for students to be reasonably well informed when deciding whether or not to continue with the subject for career reasons once it becomes optional. Furthermore, a significant proportion of this material should be 'applied', so as to indicate the uses to which such knowledge is put. Indeed, not only should it be applied, but courses should indicate how people make use of it in employment. However, despite attempts to introduce more applied material into a number of science courses, such material, and not only in science courses, is often considered of lower intellectual worth than 'pure' knowledge (Pring *et al*., 2009). Such an attitude, aside from being narrow-minded, is probably counterproductive; some students are attracted by learning material that they can see might lead to satisfying employment.

By now it might be argued that what I am proposing for science is not that different from what is often taught in science nowadays, albeit that there seems to be more emphasis on applied science. To this I respond in three ways. First, in my experience, too often science teaching does not give due consideration to its aims or to the interests of all its learners, instead serving up a diet that appeals to the tastes of only a minority of those required to consume it. Second, some similarity with what currently sometimes takes place in science classrooms is encouraging as it suggests that these proposals are not unrealistic. Indeed, at various times, and to a greater extent in some courses than in others, science education has tackled the issue of its aims – although always within the presumption that science (or the sciences: biology, chemistry, physics and, sometimes, earth sciences) would remain named on the curriculum. Third, there are a number of ways in which a science curriculum that starts with aims would be likely to differ from one that starts with what is typically taught. I will give two concluding examples.

First, there seems to be an implicit presumption in much of the curriculum debate in science education that there should be an equal representation of biology, chemistry and physics in each school year. However, wouldn't it be better to teach less physics and more biology in primary schools? Much of physics is quite abstract and difficult, not only for pupils to learn but for teachers to teach. For example, some primary science curricula require pupils to be able to show the direction in which forces act on objects and to appreciate the implications for motion when forces are not balanced. Why don't we leave this to later when students are naturally better able to reason abstractly (Shayer and Adey, 1981)?

Second, a curriculum that takes seriously human flourishing will give more weight to certain science topics and less to others than the present curriculum does. Perhaps the most important scientific question that will face those who are currently in schools over the course of their lives is the extent to which humans can live sustainably.

Some of this, of course, can be covered in geography, but surely biology, chemistry, earth science and physics should include more material than is currently the case on the related issues of agricultural production, atmospheric pollution, energy/fuel production and usage, climate change and ecosystem conservation?

Finally, I would make the point that more important than the words on official curriculum documents is how teachers teach. Science teachers who believe that science can make a major contribution to human flourishing will teach in ways that communicate that belief to many of their learners. Such teaching is likely to be more engaging to many learners and my prediction is that it would help many students to retain an interest in science who would otherwise lose it.

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