Sustaining the Spirit of Nuffield?

Jonathan Osborne, School of Education, Stanford University

First, let me say that I come not to bury Nuffield but to praise it. In doing so I hope to raise a few questions about what or whom might be attempting to stab their work in the back but more importantly a set of issues which I hope the panel that follows will respond to.

Science Education has come a long way in the UK since its early beginnings. In its early days science had to fight for its place. In England the early spur was the Great Exhibition of 1851. This peon to the achievements of science and technology made society aware of two things a) the extent to which the achievements of science and technology were now part of the cultural fabric of society; and b) that society could only be sustained if there was a continuous supply of individuals with the skills and knowledge to support that industry.

But it had to fight its corner against those who saw no such need for people to be educated in anything other than the 3 Rs and those who saw the proper education of an elite as one that was deeply rooted in the Classics and the humanities. Science and technology were a necessary evil but did not offer a proper training of the mind. Science had nothing to say about the human condition.

Spirited efforts to develop a coherent theory of how science education could develop the critical and inquiring spirit of the scientists came with the work of H.E. Armstrong and his use of what he termed the heuristic method. One of his early students, Charles Browne was to become a teacher of science at Christ's Hospital and this is a sample of one of his lesson plans. Written on the second page he writes:

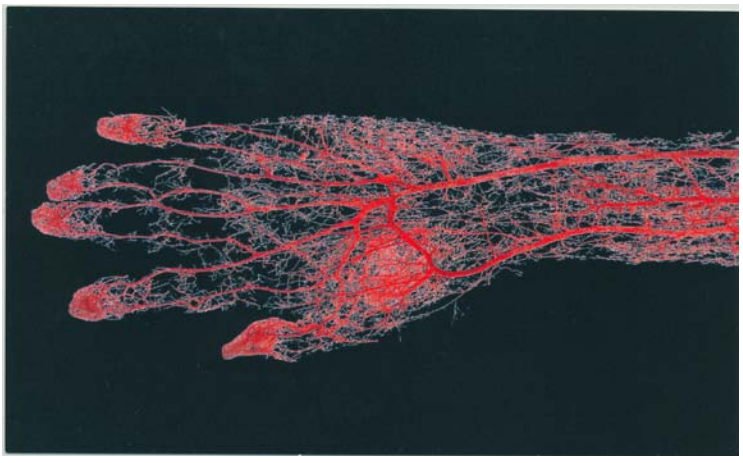
> ***"Teaching Principles: Simple suggestions mainly by questions – no telling. Teacher's attitude one of co-inquirer – must not be an authority. If a fact or date has to be given, it should be obtained from a book and the authority quoted, thus lead to right use of books – for checking and enlarging on experience, it enables the teacher to assume the role of inquirer as much as he wants the boys to do."***

Now we may make all kinds of criticisms of this view – the main one being that this is a form of deceit. Instruction does have a goal. There is a singular answer. The students know that and so does their teacher. But carefully managed the illusion that the students are engaging in a process of discovery can be carried off. This after all is what captivates students about science. You see it in the following quotes from students' views about science:

> ***"I like doing experiments because it's fun and you find out things. It encourages your mind" (8 year old boy)***

> ***"Scientific research is about unravelling mystery, it is really interesting and when I was looking at that gene for my project and I got the results out and thought isn't it weird?……and trying to find a connection that might work that might explain it and it was like detective work really and I really, really enjoyed just being able to find a reason why that was happening. I got a real buzz from chasing that up." (3rd year undergraduate).***

What these students see is that science liberates us from the shackles of received wisdom. Knowledge of the material world is not some kind of god given entity but out there to be found, created. This to my mind is the spirit of Nuffield. It has attempted to convey that there is something fundamentally exciting about science – something that lights the imagination – that child's mind is not a vessel to be filled but a fire to be kindled. Science both challenges our simple preconceptions – the idea that day and night are caused by a spinning Earth rather than a moving Sun, and shows us a simply awesome picture of a world – for instance the beauty and complexity in this picture of the human hand.



Now sustaining that fire depends on people who have passion, imagination and conviction. But, is the national curriculum dampening that fire? For instance, a little under a 100 years ago, the great American educational philosopher, John Dewey pointed out:

> ***"The dictation, in theory at least, of the subject matter to be taught, to the teacher who is to engage in the actual work of instruction, the attempt to determine the methods which are to be used in teaching mean nothing more or less than the deliberate restriction of intelligence, the imprisoning of the spirit."***

Dewey's quote raises my first challenge for the panel:

Challenge 1: In an era of National curricula, are we in danger of extinguishing the light that has been the passion of hundreds of science educators?

For there is little doubt that it is Nuffield that has lit that fire for many of the people who are here with us tonight. Through its funding is has placed its faith, and its money, in schemes and people that would help to improve the quality of the student experience.

For those of us who suffered the teaching of science as a set of unequivocal tablets of stone, the Nuffield courses of the 1960s offered a new vision of the world. No longer was science to be believed because of the authority of the text but rather the evidence was to be presented through new, innovative and exciting laboratory work. Indeed, the experiments Nuffield courses offered effectively gave the explicit message that so confident was the teacher of the scientific account of the world that they would even permit the student themselves to perform the investigation.

And, many of these experiments and approaches stand out as highly innovative and creative. As a teacher of secondary physics in the 1970s, the kits for teaching about electric motors and dynamos were so simple and neat that my students and I had many hours of fun. The innovative ideas for teaching about waves, radioactivity and thermodynamics in Nuffield A level physics likewise stand out as great achievement of how to communicate the complex in a simple and effective manner. Those courses may have come and gone but they have left an

enduring legacy embedding within the culture of science teaching a set of pedagogical practices about the kinds of experience students should be offered if science is to engage their imagination.

Why were these courses necessary? Because the subject had become dominated by a pedagogy which demanded rote learning and where the subject had little relation to the outside world. The young student has a prospective vision – their life is to come. What excites them is the technology that surrounds them and the possibilities of the future. A physics course that starts in the 18th Century and just about manages to drag itself into the 20th Century with the discovery of the neutron hardly excites – a sentiment captured well by the following comment by a young, 16 year old student:

> ***"The blast furnace, so when are you going to use a blast furnace? I mean, why do you need to know about it? You're not going to come across it ever. I mean look at the technology today, we've gone onto cloning, I mean it's a bit away off from the blast furnace now, so why do you need to know it?"***

Science may now have won its place on the curriculum and even defeated those who would argue that Latin and Greek were the pinnacle of an excellent education. After all, it is now Classics that has to fight for its existence whereas science is taught from the age of 5 up to all students. Indeed, it is one of the 3 subjects that are tested every 3 years by PISA.

But if the feeling embodied by the quotation is widespread does science deserve a place at the curriculum high table? For the economic rationale only justifies a science education for the minority who might choose to pursue science as a career. If science is to argue that it is essential for all, then there has to be a utilitarian argument, a cultural argument or a democratic argument. To its great credit, this was a baton which Nuffield took up developing Nuffield Junior Science for Primary teachers to take the teaching of science beyond Nature Study (something which they have continued with their support for the Teaching Primary Science materials in 1975, the SPACE project and Nuffield Primary Science in the 1990s); Nuffield Secondary Science to provide a worthwhile science course for what the Newsom report termed 'Half our future' – those who were not going to grammar or private schools; Nuffield Combined Science as a course for the early years in comprehensive schools; and Nuffield Science 13-16 for pupils of average ability.

As for the utilitarian argument, it used to work. The lesson on how to wire a plug that others and I performed in the 1970s gave physics some salience. But as technology has become more and more opaque, it is a difficult argument to make for anybody other than the biologists. There is nothing much left that you can readily 'fix' with the limited knowledge that school science offers. The democratic argument that knowledge of science will enable students to participate in many of the contemporary public debates lacks immediacy for many students who sense of social responsibility is not well honed at the age of 16. It also lacks empirical justification as an analysis of many contemporary science debates conducted by Jim Ryder shows that they rarely draw on knowledge of school science. Rather, I would argue that school science needs to stand its ground and make the cultural argument – that in the words of Herbert Spenser it constitutes the best that is worth knowing.

The most well-known attempt to make this argument was by C.P. Snow. Snow argued that anybody who did not know and understand the implications of the second law of thermodynamics could hardly be considered educated. What has school science done since the 1960s to address Snow's challenge or to answer Leavis' vituperative response that science does not speak to the human condition, that science and scientists if not restrained will become the dominant cultural imperative, and that science devalues the beauty of the world – a taunt made initially by Blake when he penned the verse:

> ***To see a world in a grain of sand, And heaven in a wild flower, to hold infinity in the palm of your hand, and eternity in an hour.***

Now, perhaps not surprisingly, I do not have much truck with that argument. The first response is the beauty revealed by the slide of the hand shown earlier. The second come from this slide of a young woman suffering from the ills of smallpox which shows how science has contributed to relieving human suffering and misery.

But this cursory review does raise my second question for the panel which is:

Challenge 2: What justification would the panel give for the place of science on the curriculum today? How would they respond to a 16 year old who asked why they had to learn all this information that they were instantly going to forget the day after their GCSE? Indeed, I have one colleague whose daughter took great delight in burning her science textbooks the day after her examination. In short, in an age of Google, what is the point of asking students to memorize and recall information when a computer does that much better?

And it is here that we must again praise Nuffield for the work it has done. They have supported the idea that there has to be a better argument for the goal and purpose of science education. In short that there has to be more to science than content. You see it in the writings of Gordon Van Praagh, an early Nuffield pioneer who in describing a lesson on the oxidation of copper says that he begins his lesson not by stating the bare facts – something which is so mind numbing to young student – but by asking a question – why does copper go black when it is heated? What could this be and why? This is what he writes:

> ***'Smith says 'I think it is soot from the flame'.***
> ***'Good idea'. I write on the board 'Smith's theory – the black stuff is soot'. 'He may be right', I say. 'Any other ideas?'***

'Yes, sir' says Robinson, 'I think it's an impurity driven out of the copper by heat.' So Robinson's theory goes on the board too.
'I know what it is', says Solly whose older brother is in the Fifth form.
'If you know, you will have to prove you are right – we'll add it to our theories.'
Solly's theory: 'the black stuff is formed by the air acting on the copper'.
'How shall we decide who is right?, I ask. I get them to suggest three experiments to test the three theories.

Beginning with Nuffield O level physics and its attempt to trace the development of our ideas about Earth and Space, then Nuffield Science 11-13 which placed a greater emphasis on literacy in science and its attempts to explore how science works, Nuffield has led the movement to put substance into the argument that science offers an introduction to critical rational thinking. In the 1990s it supported Ros Driver and myself in the work that led to *Beyond 2000* taking that further with its support for the AS on Public Understanding of Science and then the enormous investment in Twenty First Century Science. To my knowledge, and I have now seen a lot of curricula in many countries, this is a truly innovative curriculum. At its heart it embodies the liberal notion that science offers an opportunity to develop both a students' intellectual capacity and their moral capacity by considering the social and contextual implications of this idea. This course is not a debasement of school science as its misinformed critics would have us believe but a reframing of what kind of knowledge is of most worth. As long ago as 1952, Bernard Cohen the first man to get a PhD in the history of science from Harvard was to write of the traditional science course:

"Here we find a belief in the usefulness of unrelated information such as the boiling point of water, the density of various substances, the atomic weight of different chemical elements, conversion factors from one system of units to another, the distance in light years from the earth to various stars...All too many science courses have attempted to make students memorize a series of dry facts which no practising scientist knows."

Are the current movements in the National Curriculum in danger of returning us to this state of affairs?

Beyond 2000 made the argument that it was essential to have some knowledge of how science works if you were to engage with the new knowledge that science presents. The new framework for the next generation science standards just published in the US argues that students must have an opportunity to engage in 8 scientific practices during their education and reflect on their role in science. The PISA assessment framework for 2015 which will set the basis for the items in science argues that there are three elements of knowledge to be assessed – knowledge of the content of science, knowledge of the procedures that science uses to derive its knowledge and epistemic knowledge which is how such procedures enable science to derive the knowledge it does. Thus, there is a clear international belief that students do need to know something about how science works. It is simply not enough to tell students what we know but we must also communicate how it came to be and why it matters.

This requirement has to be balanced with the fact that the cup of knowledge in science does overflow. Having worked on the panel that produced the next generation science standards for the US I can tell you that the list that the Earth Science community produced for inclusion in the K-12 curriculum would have taken not one school lifetime but several. We can only give a partial account of what is known about science.

This leads me to my third and final challenge to the panel which is:

Challenge 3: What is the account of science that they would wish us to offer to young people today? What should it include and what should it not include? And more importantly, who should build that vision? Do they really believe that it can be left to a process of letting a thousand flowers bloom – individual teachers working in isolation? And, if not, who will carry forward the baton that Nuffield that carried to date?

In short, who is to nurture the passion, the vision that inspires and frames the teaching of science and the spirit that Nuffield has worked so hard to establish?