CONFERENCE REPORT

The National Value of Science Education

New insights into shared challenges

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21st-century science education: a global step forward

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The underlying imperative

If you ask teachers what the purpose of a formal science education is, they might well reply that it is to ensure our supply of future scientists. And if you ask science museum curators why they seek to engage younger children, the answer could be to entice them into the classroom for the same purpose. This response feels natural, innate – isn't that what science education is all about?

But now, it feels as if this instinctive reaction no longer represents the full story. During the course of the conference, I got the sense that the *raison d'être* of science education was in the process of shifting and, by the end, this impression had crystallised in an atmosphere of remarkable consensus. Held under cold, bright skies at the UK's National Science Learning Centre (NSLC) and populated with delegates from all over the world – from formal and informal education, policy, industry, foundations, charities and think-tanks – the conference agenda gave science education a vigorous shake and put it under the microscope. What is the purpose and value of science education – and just as importantly, *who* is it for?

According to Clare Matterson of the Wellcome Trust, the conference came about because of growing evidence suggesting a decline in students' interest in science. After all, we are living in times when some parents decide to ignore prevailing scientific wisdom on the safety of a crucial childhood vaccine, and when certain governments dictate that genetically modified crops are too dangerous to permit or that keeping the oil industry happy is more important than taking more drastic action to curb carbon emissions. When considering these examples, the logical conclusion I draw is that the recommendations of science and its practitioners are no longer to be trusted, that science is just one opinion among many that needs to be weighed against one's own gut feeling. It is perhaps no wonder, then, that interest in science is waning along with this trust, and that the education sector feels a radical change is needed to counter the malaise of all of society, not just that of those destined to become scientists.

Setting the stage

On the first day of the conference, before the morning lectures, I wandered into the Atrium of the NSLC, where delegates were hanging their posters, colourful little snapshots from the vast album of public engagement. The enthusiasm was so great that these hangers were already being offered business cards and getting a friendly grilling about the content of the posters before their work was completely pinned up. Inscribed on the circular wall above the chattering crowds, the quote from Johann Wolfgang von Goethe seemed particularly apt: "Science and art belong to the whole world, and before them vanish the barriers of nationality." And on the periphery, teams of schoolchildren were busy

recording the proceedings for a podcast and a mini-documentary, and video screens emitted shifting images and music – more students' works, adding to the amiable chaos.

The keynote speech, given by demographer Michael S Teitelbaum from the Sloan Foundation, presented the idea that was to set the tone for the rest of the conference: we actually don't need more scientists. In fact, with only a few exceptions (such as subspecialities like engineering; or in particular countries, such as Korea), we are producing more than the system can absorb. Teitelbaum has been broadcasting this warning over the past five years, but clearly the message is not penetrating. For example, as recently as March 2007, a report from the Confederation of British Industry called for a doubling of science and engineering graduates over seven years to prevent skilled jobs from going overseas, and similar proclamations have been made in the USA, Europe and elsewhere recently. But Teitelbaum's research shows that surplus is the reality now and, although forecasts can never be certain, there is scant evidence of a future shortfall either. Meanwhile a generation of PhDs face a "nasty hard landing".

Teitelbaum was not in any way suggesting that science education is not important – but it is "an annoying fact", he said, that scientists and engineers make up less than 5 per cent of the global workforce. So from an economic perspective, we need to ensure that all STEM (science, technology, engineering and mathematics) graduates and PhDs can make a meaningful contribution even if it is not to do research. This is not necessarily difficult: he called science knowledge "as essential as literacy was to the 20th century" for the general skilled workforce today, and showed evidence that STEM graduates doing non-STEM jobs still earned more money than their non-STEM counterparts. (Or, as Nick Jagger from the Institute of Employment Studies quipped, "Scientists are not branded on the forehead 'Not to be employed outside of science'.") So whereas channelling education solely to create even more of a surplus of specialists would be inappropriate, good science education for all children will lead to an increase in national productivity, wellbeing and informed citizenry.

Another talk in the first day's session that caused a stir was that of Svein Sjøberg from the University of Oslo, who presented the most recent results of the ROSE (The Relevance of Science Education) Study. Ongoing since 2001, ROSE is an international comparative research project designed to illuminate factors important to the learning of science and technology as perceived by the students themselves. One of the most striking correlations that has emerged thus far is that the better students do at science, the more they dislike it. Or as Sjøberg put it, "the negative atmosphere of science education can linger far beyond the facts".

Perhaps one of the most enthusiastically greeted talks came from Mary Arber, who spoke about Junior Café Scientifique. The audience was so inspired that they staged a rebellion when the chair denied time for questions, simply talking over his protests until he surrendered with good grace. Arber stressed the radical format of the 'Café Sci' process, in which students subvert the normal classroom model and take full control. "We don't care what students go on to do," Arber said. "There is no agenda for

the scientist pipeline." Maybe, I mused, the students can sense this, when they'd run a mile from purposeful encouragement in that direction? And when comparing the price of a Café Sci – a few soft drinks and snacks – to that of a science museum, one really starts to wonder which is more effective. Unfortunately, as with many such informal education projects, we have no hard evidence how effective Junior Café Sci really is (although Arber has just embarked on a research project to find out).

Nuts and bolts

On the second day of the conference, after all the abstractions of the plenary session – too many to describe here, alas – it was time to break into three workgroups, covering curriculum/assessment, teaching, and informal science. I chose the latter group, intrigued to see what would happen. In our stream, two sorts of approaches seemed to battle it out: the thinkers and the doers. The thinkers wanted to spend most of the time on 'meta'-activities such as defining terms and coming up with common nomenclature; they even wanted to abolish the term 'informal education' and replace it with something less oppressive. The doers, on the other hand, were quite happy to bash out long lists of concrete projects with little regard for semantics, reasoning that most of us were on the same general page. Cultural differences also seemed to rear up here, and language barriers, where they hadn't been apparent in the main lectures. Consensus, it seems, isn't so clear when you're face to face with the finer details.

After hammering out our ideas and going to lunch, we repopulated the auditorium to hear a distillation of all three efforts. I think it's worth summarising the main issues of importance that emerged from each stream.

1. Curriculum and assessment

Since we all seem to agree that creating a scientifically literate society, as opposed to just fostering future specialists, is now a major focus of science education, the challenge seems obvious: can we educate both streams in the same system without turning people off or doing either group a disservice? Can there be a one-size-fits-all approach in curriculum, at least up to a certain level in the educational system, or must two separate approaches be developed? What about the content – do we sacrifice depth for breadth? As speaker Bob Tinker said, "The brain needs specifics to develop; a generalised training doesn't nourish it." More concretely, AstraZeneca's Aileen Allsop pointed out that her newest employees didn't seem all that prepared for industry.

All agreed that students feel that science is not being made relevant to their lives, so shouldn't we be teaching more about the nature of science and its methods rather than facts? As Sjøberg put it: "School science currently doesn't show the relevance for future jobs, in general, nor for our way of living, nor does it lead to increased curiosity or enhanced critical attributes, career possibilities or respect for nature."

Ironically, he also pointed out, the humanities are far more critical – whereas science seems just a collection of facts.

Along with the curriculum, testing and assessment also need to be overhauled. Current assessment methods don't encourage the right classroom practice, because the curriculum drives assessment. Actually, that's backward: we need to decide what we want students to achieve, then design an assessment that measures whether the teaching has succeeded. Also, we need to assess values and attitudes as much as knowledge, so that our teaching methods can constantly adjust to the fluctuating barometer of their youthful recipients.

2. Teaching

There was a veritable cry for a radical change in teachers' education, with a view that current pedagogical methods are in need of rapid and regular refreshment. But obviously, teachers will need support in this transition. We need more research in order to understand teachers' needs, especially early on in their careers. Teachers also need a clearer career ladder, as well a more comprehensive and joined-up professional development scheme from pre-service through to retirement. And importantly, we need to find a way to make science teaching a prestigious and well-compensated profession to attract the best and brightest – and to retain them, which seems to be even more of a problem. We must look to countries where science teachers are esteemed and ask why. And, simply, we need to increase teachers' salaries if we want to get anywhere.

3. Informal education

Graham Durant of Questacon likened the worldwide informal effort to "a thousand flowers"; but is this a problem, he asked, or cause for celebration? Probably a little bit of both. Here is but one tiny example. Science communicator and physicist Averil Macdonald, the after-dinner speaker, told us one of her most experience-tested techniques to interest children was to specifically *not* tell them about all the famous discoveries, lest they think it's all been done. Instead she tells them about all the tantalising gaps in knowledge – which they can dream of filling. There must be thousands of tricks like this out there, if only they could be collated and shared.

There really is a sense that informal learning is on the ascendancy, as this seems to tie in best with the creation of science-literate citizens. There is a sense of excitement and, equally, urgency about being able to assess which methods work and which don't, to disseminate that information, andto use the model as a true 'incubator' and bring elements that work into the formal classroom setting – without being meddlesome. There is no doubt that the lines between formal and informal education will probably start to blur as the incubator continues to bubble away. But we need to know better how to harness the huge, diverse array of resources worldwide. If we can't quite manage to centralise these efforts or entirely eliminate their redundancies, then at least we need gatekeepers and brokers, an effective way to share best

practice, and extensive research on which approaches are the most effective. Such research should address not only whether young people's scientific knowledge increases with a given informal strategy, but also if it affects their attitudes and perceptions towards science in general.

Next steps

So where do we go from here? The conference organisers, after talking us through their official reporting strategy (of which this essay is one aspect), seemed surprised when the audience again staged a mini-rebellion. They were not, it seemed, content with merely cataloguing and disseminating the conclusion among the delegates. Instead, they expressed an ardent wish to take things farther. Would the reports, they wanted to know, be sent to governments, and would the recommendations be codified into concrete international policy? "I hope someone is writing these down," NSLC Director John Holman murmured as people raised their hands and filled the air with the acronyms that needed to be approached: UNESCO, OECD, ICASE, IOSTE, ICSU. The main purpose of this conference, Holman told me later, was to decide what research the Wellcome Trust along with its partner organisations would fund into clarifying the main issues. But I can very well understand the desire to make these ideas *stick*, somehow, to as many educational systems as will allow it. Maybe it's too ambitious, and too soon, and reflection and research is required – but being more a more a doer than a thinker, I can sympathise nonetheless.

All of these ruminations, I feel, deserve to end with some thoughts about the children who ran like bright threads through the weft of our two days in York. These small, bright people, furiously filming and editing, pretending to be microvilli in the digestive tract during an interpretive dance, giggling and poking each other during lunch, were forceful reminders of why we were all there in the first place. When a young boy in a short film produced by the London School of Hygiene and Tropical Medicine said, "I wanted to find a cure for malaria but found out later it was too ambitious", I was moved. Not because he was naive, but precisely because he was wise enough to see his own limitations, imposed by socioeconomic circumstances. But also, from the adult perspective, I could see that these limits might well be surmountable with a lot of effort and luck, and I wanted to tell him not to give up his dream. When the final podcast was aired, we laughed at its high-pitched presenter – not because he was amateurish, but precisely because he sounded so adult and competent, infused with humanity and humour. That these simple activities done over a very short time could make a big impact – on us, on them – is a testimony to the power of rolling up the sleeves and *doing*. With such raw material as youthful energy and enthusiasm, coupled with the right research and subsequent informed modifications to the education system, it is hard to believe we could fail.

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The Wellcome Trust is the largest charity in the UK and the second largest medical research charity in the world. It funds innovative biomedical research, in the UK and internationally, spending around £500 million each year to support the brightest scientists with the best ideas. The Wellcome Trust supports public debate about biomedical research and its impact on health and wellbeing.

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