**The Royal Society**

**Vision for science and mathematics education teacher workshop report**

**No. 4. National Science Learning Centre, York**

**Summary**

In June 2013, the Royal Society embarked on a series of meetings with teachers and other education experts across the United Kingdom, with a view to gauging professional opinion on how science and mathematics education could look in 20 years’ time. The four discussions detailed in these reports took place in England. Further seminars, in Belfast and Cardiff, will take place in the autumn.

This report provides a summary of the discussions and views expressed at the workshop held on 20 June 2013 at National Science Learning Centre, York. The workshop was specifically geared to discussing the Vision for science and mathematics education that the Royal Society’s Vision Committee is currently developing.

*The Vision*

‘We want inspirational education systems that will deliver both scientifically and technology informed, engaged citizens and appropriate numbers of qualified people who wish to take up science- and technology-based careers.’

*Principle 1*

‘An excellent teaching profession is at the heart of an inspirational education system.’

*Principle 2*

‘Learning and active involvement with science and mathematics supports the development of informed and engaged citizens.’

*Principle 3*

‘Assessment and accountability systems must recognise a broad set of qualities beyond subject knowledge.’

Participants, who were split into two groups and guided in their discussions by Royal Society facilitators, were asked to grapple with the Vision Committee’s Vision and the three principles upon which it is built.

Discussions ranged extensively over what the priorities for the future should be given, for instance, expected major ‘drivers’ of change, and were informed by the varied concerns and opinions expressed by participants as to the problems and challenges facing science education today.

While an attempt is made to cover the debate as fully as possible, this report does not capture every comment. In order to facilitate free discussion, it was agreed that full details of each speaker would be kept anonymous. Nonetheless, in many cases, it is possible to provide outline details about the sector in which speakers work.

Warwick Mansell

**Discussion of Principle 1. ‘An excellent teaching profession is at the heart of an inspirational education system’**

This seminar contained people from possibly the widest spread of education jobs, with university academics, school leaders, a senior awarding body employee, a retired teacher who once worked for the Institute of Physics and a public relations professional who is a former physics teacher joining primary and secondary teachers among the participants. Perhaps unsurprisingly, then, debate on each of the principles, starting with the first, was wide-ranging.

There was quite an extensive discussion, in relation to this principle, on the issues of **work/life balance**, **salaries,** the **status** of the profession and whether good science and maths teachers should be **encouraged to remain in the classroom** or to go into school management. The related issues of **continuing professional development**, teacher **shortages** and the case for an **independent regulatory body** all received an airing.

*Teachers’ pay and conditions*

A primary teacher who used to work in industry kicked off debate on this topic with a personal account of his experience in the two jobs.

He said: ‘I worked in industry for 15 years and have now been teaching 13 years. I left Cadbury–Schweppes, where I had been making washing powder, to become a teacher. My last salary in the chemical industry was twice what I’m earning now.’

‘In terms of work–life balance, I’m still working now [early evening] and I set off for school at 6 am today. I’d also be retired by now if I were still in the chemical industry.’

He suggested that his enthusiasm for teaching meant he would think about the job even after work, which had not happened in his former life.

He added: ‘I’m quite an enthusiastic teacher: that’s why I’m here and not in industry. But, by heck, I’m tired.’

An experimental nuclear physicist, taking part in the discussion because of his work with a university’s school outreach programme, said: ‘If you are looking for people with science degrees to teach, they are being offered jobs in science on a lot of money. There are thousands of pounds between what you are paid for in teaching and what you get in industry. That’s an issue for government.’

A facilitator suggested that this was always going to be a problem, whereupon a teacher responded that it was not enough simply to accept there would always be salary differentials; these had to be challenged.

‘You should think about the fact that if you want to get teachers in, you have to pay them’, she said.

Another teacher said that some trainee teachers were starting courses but then ‘they are saying that teaching is too hard. ‘I can go and work as a researcher, where I can earn more money and it’s not as hard as teaching’, said the teacher.

Another teacher, a head of maths at a secondary school, said: ‘I have just passed the salary of a friend who left university in 1990 and went into industry.’

There was some discussion suggesting that the current government’s ruling that schools no longer had to follow national pay scales for teachers presented an opportunity for management teams to reconsider their recruitment strategies, and whether they should pay good maths and science teachers more.

A teacher said that schools would be limited in their room for manoeuvre, however, as they could generally only get more money by expanding pupil numbers. If the budget remained static, heads could only pay for priority staff by cutting spending elsewhere, typically on salaries. The teacher said: ‘You either have to increase your numbers or cut the amount you pay your teaching workforce in certain areas in order to pay certain people more.’

*Teachers’ status*

This led naturally into a discussion about status, with the former chemist now working in a primary school saying: ‘I used to do analytic chemistry; it’s not nearly as exciting as working in a school. We have to tell people what a fantastic job this is, working in a school.’

In other words, attracting and keeping people teaching did not entirely come down to salary levels, he suggested.

A head teacher said, however, that the professional would always have an image problem so long as teaching’s core working hours were as they were. She said: ‘As long as teachers are working 40 weeks a year, and people are looking at a 9–4 job for 40 weeks a year – even though we know teachers do not do that, but that’s what the public sees – until we change terms and conditions and teachers are seen to do a professional job, we are going to be fighting this battle for status.’

A university computer science lecturer said that academics also operated in a system which offered extensive holidays to the students they taught, and, like teaching, was now subject to a great deal of accountability. Yet academia seemed to have retained its status, in contrast to the situation often facing teachers, he said.

*Good teachers staying in the classroom?*

There was quite a heated debate on whether good science and maths teachers should be encouraged to continue offering that teaching expertise directly to pupils, or to take their talents into management.

A retired physics teacher said: ‘The key is to help any good science teacher stay in the classroom. Too many of us at my age got promoted too early. A lot of people went on to become head teachers and didn’t teach. That was wrong.’

He added: ‘I have suggested on many occasions that, rather like in Canada, the head teacher should still be teaching but have a manager of the school who looks after the management but not the education’.

A current secondary head teacher replied: ‘I am sorry, I have to disagree. I have spent the past 20 years in leadership in a school and I have never thought that I could not influence what was going on in the classroom.’

He continued: ‘I taught from year 7 up to A-level for many years, but once I became a senior leader, I was not teaching as much, and for the last 10 years I was not teaching very much at all. But I was in classrooms, and I was helping to train other science teachers. School leaders do not do administration.’

The retired teacher replied: ‘I did not say they are doing administration; I just know they are not teaching. It’s not good enough’.

*A Royal College, chartered teacher status and teacher shortages*

Participants were asked what they thought of the notion of an independent body to regulate, and possibly promote the professionalism of, teachers.

One teacher replied: ‘That sounds great, but we already have teacher unions and subject associations. What are we going to get rid of [to make way for a royal college]?’.

Another said: ‘Membership of subject associations has fallen because everyone is now a member of a union [and people might not want to pay two membership fees]. A royal college would be on top of that, so might struggle.’

The awarding body employee then offered the view that her employer paid for her to be the member of a subject association, because it was seen as essential that she engage with her subject.

There was then some suggestion that more important than a royal college might be the need to give a higher profile to the ‘chartered science teacher’ designation, with one participant suggesting it should be made impossible to become head of maths or science without it.

A teacher hit back, though, saying: ‘I’m currently working in a school that cannot get a head of maths, whether or not they are chartered’.

On the issue of shortages, a school leader said: ‘In terms of recruiting newly qualified teachers, we are not recruiting enough physicists and mathematicians’.

*Continuing professional development (CPD)*

A secondary head of maths said: ‘In the medical profession, it’s just taken as a given that you keep up with research. It’s a professional requirement that you are logging what you are doing and I’m not sure we’ve got the approach right in schools.’

Another teacher said that it came down to giving teachers the time in their calendar to undertake CPD. The retired physics teacher said: ‘When I worked for the Institute of Physics, it provided a lot of development time for teachers going on courses, but I had to end up running them at weekends because we did not actually get the teachers to attend because they were needed in the classroom’.

Another participant responded: ‘Yes, the IoP are big on this. The trouble is: there is almost a 50:50 split amongst teachers out there. Half say “this is great”, while the other half say: “this is more time than I’ve got, it’s not on the syllabus, so why should I be here?”’.

The awarding body employee said that, in Singapore, there were ‘pathways’ for teachers entering the profession to follow, with some choosing one which was always designed to lead to classroom teaching, while others led to management, or to research. She said: ‘n Singapore, you are required to do 100 hours a year of CPD. It’s a requirement, so the individual pathways are easy to facilitate.’

**Discussion of Principle 2. ‘Learning and active involvement with science and mathematics supports the development of informed and engaged citizens’**

Themes included under this Principle, which centres on the content of what is taught, included the **nature of science and mathematics knowledge** and the case that **mathematics is a language**; the need to build on young people’s **sense of wonder** in scientific discovery; and engagement with **real world science and scientists**.

*The nature of science and mathematics*

The nature of the subjects of maths and science was discussed, with some commenting on the hierarchical character of learning, in which prior knowledge is needed as a foundation for further learning in contrast, it was suggested, to other subjects.

A teacher said: ‘If you have a disposition to study history, you don’t need to know about the Tudors to study World War 1, but that’s not the same in science.’

A facilitator observed that the Vision Committee believes that science and maths should be studied until 18 for that reason: ‘You cannot teach quantum physics unless you, and your pupils, have a very good grounding in [more basic] science and maths’.

One of the participants, an advanced skills teacher, said: ‘That’s what separates the sciences and maths from other subjects: we have that central framework [of subject material], but what is it? Do we need to teach, for example, Newton’s three laws of motion to 14-year-olds? Should that be changing?’

The retired physics teacher said: ‘You cannot ignore Newton’s laws. But you do not need to teach every darn thing [that might be possible to set out in a curriculum].’

There was also an interesting exchange of views between two university academics as to whether the unique language of mathematics made it more challengingly abstract for young people to master, or whether its defining quality was not its uniqueness but its ubiquity.

‘I think mathematics is a language [but] it is a particularly problematic language because it has no native speakers’, said the computer science lecturer.

‘But the important thing about maths is that it’s a universal language: I have talked to people who do not speak a word of English about maths. The whole world should be speaking maths’, responded the nuclear physicist.

‘But there are no native speakers: imagine speaking German if there were no Germans. It’s very difficult’, came the reply.

*Encouraging a sense of wonder*

Aside from this debate, the primary teacher who once worked in industry reiterated comments expressed in previous seminars that a central goal of science education had to be to retain young children’s enthusiasm for discovery.

He said: ‘For me, it goes back to that need to support that sense of wonder, and initiating that in children at a young age, and curiosity, and resilience. So that our students can see the wonder in science learning, that is all around them. That’s something we should be embedding in learning all around the world.’

The secondary head of maths said that, in an interview, he had been asked why he was teaching maths. He said: ‘Lots of people say “it’s about the functionality of it, so that young people, for example, can add things up as they go around the supermarket” – as if any of us does that! The answer I gave was: “It’s that sense of awe and wonder. It’s about patterns, connections, a different way of thinking that children do not get in other parts of the curriculum”.’

The advanced skills teacher said: ‘It’s very easy, when you get into the routine of teaching, to lose that sense of the wonder of maths and science. You need to be able to keep re-energising it. I have had to deliver outreach courses…and the ones which seem to have had most impact are the ones where I have worked with a real scientist. It’s still good to hear someone say “this is why I chose the [career] route of science”.’

*‘Real world’ science?*

How much reality should be communicated to pupils, though? The truth was that to succeed in a science career, you often needed persistence alongside enthusiasm for your research, comments by the awarding body employee implied.

She said: ‘My first job was with [the pharmaceuticals company] Pfizer. I needed to spend the entire day pipetting. I did that, because I desperately wanted the bit of information that would come out as a result. People say that if you want to do a PhD in science, you have got to love the science, because without that, it’s going to kill you.’

Returning to the question of the curriculum itself, the retired physics teacher said that, while the current curricula and exam syllabuses were not perfect, developing new ones was expensive.

He said: ‘We need highly skilled curriculum developers, but it is expensive. I was involved in one such [partly privately funded initiative] and it cost well over £1 million. And it did not make much use of technology; if you are going to do so, that’s going to be a hell of a lot of millions.’

**Discussion of Principle 3. ‘Assessment and accountability systems must recognise a broad set of qualities beyond subject knowledge’**

The intertwined issues of **assessment** and **accountability** dominated debate of this principle.

*Assessment*

The advanced skills teacher said: ‘Our [public examination] system is just so outdated. It’s based around kids doing exams at the same time; kids all doing their GCSEs at 16, with all having to get a C. I do not understand why our education system is based around the age at the time the pupils do the exam rather than their development. Why do kids have to sit down, for example, on one Tuesday morning, 200 kids all doing their physics paper in the sports hall? Why can’t these kids do it when they are ready to do it? Some GCSE students will have spent the last six months just itching to get on to A-level, but our system says they have to be assessed on one day in the summer.’

The head teacher replied: ‘An alternative might rely on teacher assessment, with their teachers being trusted to be honest about it. Which flies in the face of league tables.’

The awarding body employee said that the biggest problem was how skills which had not been traditionally assessed through written exams actually could be assessed.

She said: ‘I was quite closely involved in the pilots of Functional Skills qualifications [in maths, under the Labour government]. The biggest thing was: how do you assess all of the things we want to assess, because it is nightmarishly complex. I can tell you what the assessment should not look like: it should not simply be multiple-choice, for example. But I cannot tell you what it should look like because it’s incredibly complex.’

*Accountability*

Moving on to accountability, there were some vivid insights into what three participants saw as the problems with the current regime, with one educationist offering allegations of seemingly serious gaming of the system at GCSE by some schools.

She said: ‘Some schools are entering children for every single exam board and they are entered at every single opportunity, from year nine to year 11, just to get a grade C. A lot of students do not even study maths in year 11 because they have already got a grade C. The A or the A\* students are suffering because they are not given the attention or time by schools [who focus on grade Cs]. There are quite a lot of brave heads of department in schools who say “we won’t do this”. But the senior leadership are saying: “it’s all about the Cs: that’s what you have to do”.’

The head teacher responded: ‘But wouldn’t Ofsted hold a school to account for this? In my own institution, they were checking that we were supporting the progress of all students [ie not just the C/D borderline pupils].’

The first speaker, though, was unconvinced. She said: ‘Some pupils have been taking the same GCSE subject through three different exam boards this summer, and they hate it.’

The issue of pupils being entered for multiple exam boards has been of concern to the regulator, Ofqual, over the past year, given that multiple entries for individual pupils were never envisaged when this system was designed, while even exam boards seem to have reservations. However, it is unclear what can be done about it.

The facilitator then asked if all agreed that schools and teachers needed to be held to account. There was no argument with that, but a further discussion on problems with the current model followed.

The head of maths said: ‘Yes, we should be held to account. But there are degrees of accountability, and the question of how the system seems to change from year to year. For example, we took a decision to enter pupils early for statistics GCSE. [Early entry has recently been criticised by Ofsted]. The maths syllabus we were doing was quite heavy in stats, so we thought, “why not”? But that was a decision taken three years ago, in which time there have been two Ofsted frameworks, so it changes all the time.’

‘Now we are going through a temporary [GCSE] system, before another setup is launched in 2015–16. It feels like we are playing a game all the time: a board game of ‘what’s the best strategy to get from here to here.’

‘How do you get enrichment when you have got this tyranny of accountability on top of you?’

The advanced skills teacher then said: ‘We have used the term accountability, but my feeling is that, when this system is saying “you have to get the Cs for your pupils”, teachers are not actually feeling accountable [for those grades], they’re feeling responsible.’

“You are accountable to someone when things go wrong, as opposed to a system we seem to have at the moment, where you are responsible for the child’s outcomes. So if the students do not reach this particular level, it’s nobody else’s fault but yours. And students can say: “it does not matter what I do, because the teacher has to get me these grades”.’

There was then some discussion on whether a ‘high-stakes’ assessment at age 16, such as the GCSE, was needed. The awarding body employee said that the usual argument coming back was that many pupils transferred between school and college at 16, so there needed to be some assessment before they moved institution. She added: ‘If you are moving to go to college, is that a good enough reason to have whole cohort assessment at that point?’

Another speaker said: ‘I don’t have a really big issue with retaining GCSE and A-level. It’s not the assessment; it’s the high stakes. They have always been high stakes for individuals, but now they have become high stakes for schools, and the pressure on schools means you now get the stupidity we have been hearing about repeated early entries.’

There was some enthusiasm, however, for one form of assessment which is not – perhaps not yet – subjected to strong accountability in terms of schools’ results: the Extended Project, in which sixth formers can complete a lengthy piece of research alongside their A-level studies.

The head of maths said: ‘Do people have experience with the Extended Project qualification? You can do a 5,000 word essay and, while we don’t have massive experience of it, there have been some very interesting projects in the first year. In 20 years’ time, if more students do this, they will be going to university with a better basis for further study. It’s about the expectation that study will be largely self-driven, with some input from the key teacher.’

**Other themes**

Two other themes were discussed: a brief concern was raised about **levels of subject knowledge among primary teachers**; and the future **role of technology**.

*Subject knowledge among primary teachers*

A secondary teacher said: ‘I have taught chemistry for many years, and some of the misconceptions that come through from maths in primary do cause us problems in secondary. If you lose people at a young age, it’s very difficult to pick them up later.’

A second speaker then raised worries that low numbers of primary teachers had a GCSE science qualification beyond GCSE.

*Technology*

The participants were asked if technology could help with some of the problems discussed above, and particularly in relation to accountability.

One replied: ‘You cannot just use technology to have pupils answering multiple-choice questions, assessed by the computer. It has to be more sophisticated than that.’

The facilitator then told the participants that Charles Clarke, the former Secretary of State for Education under Labour and a Vision Committee member, was very keen on encouraging schools to use technology to develop a ‘three-way link’ between teachers, parents and students.

Although there was little disagreement that that sounded like a good aim, the computer science lecturer then ventured that the ‘digital divide’ – with some families lacking the access to technology of others – could be a serious problem. He said: ‘The digital divide is real. Some people are excluded from services and technology in all sorts of ways. It’s not a universal solution. For this reason, e-government is a nightmare.’

The head teacher said: ‘We have a virtual learning environment [online] learning gateway. But we are in an affluent area.’

The academic said: ‘What about if you are a blind person, or one who is illiterate in English? How do you access that?’

The advanced skills teacher said: ‘In 15 to 20 years’ time, that gap will have closed’.

The academic said: ‘There will just be different technological gaps. It is always said that the next set of technology will be better, and it never happens’.