Pupils as scientists

Prize-winning pupils at Florence Brown Special School, Knowle. After conducting a study of mechanical properties of various concrete mixes, these pupils used the subject of their research to manufacture garden furniture for sale on behalf of the school.

The Scientist in Residence scheme, and other activities organized by Clifton Scientific Trust, brings together the worlds of the professional scientist and the schoolchild. ***Eric Albone*** *argues that such an interface should be a central part of science education from the earliest possible age.*

'I soon started to understand the real life of a field based research scientist, waking up at three in the morning to walk for three quarters of an hour, then settle down on an icy rock to watch a group of hares rapidly disappear over the horizon.

The insight I gained was rich, not only in frustrations and discomforts, but with the reward of the sheer joy and excitement of studying wild hares after weeks of plotting and hours of chasing.

This project involved me in work of a level far beyond school work and gave me a taste of original scientific fieldwork in the most beautiful and unspoilt part of the world I have ever seen.'

Lucie Green on her experience as a pupil member of a Clifton research expedition to the Canadian arctic.

'This view was reinforced by the virtually unanimous response to consultation, with respondents vehemently and unequivocally asserting the important and unique contribution that practical experience based on investigation makes to a full and complete scientific education.'

National Curriculum Council Consultation Report, 'Science in the National Curriculum', December 1988.

IF WE ARE concerned that as a nation we are ill at ease in a scientific world, that government and industry seem slow to seize the opportunities which science and technology offer, that we do not value the achievements of our scientists and technologists, that many fear science and that

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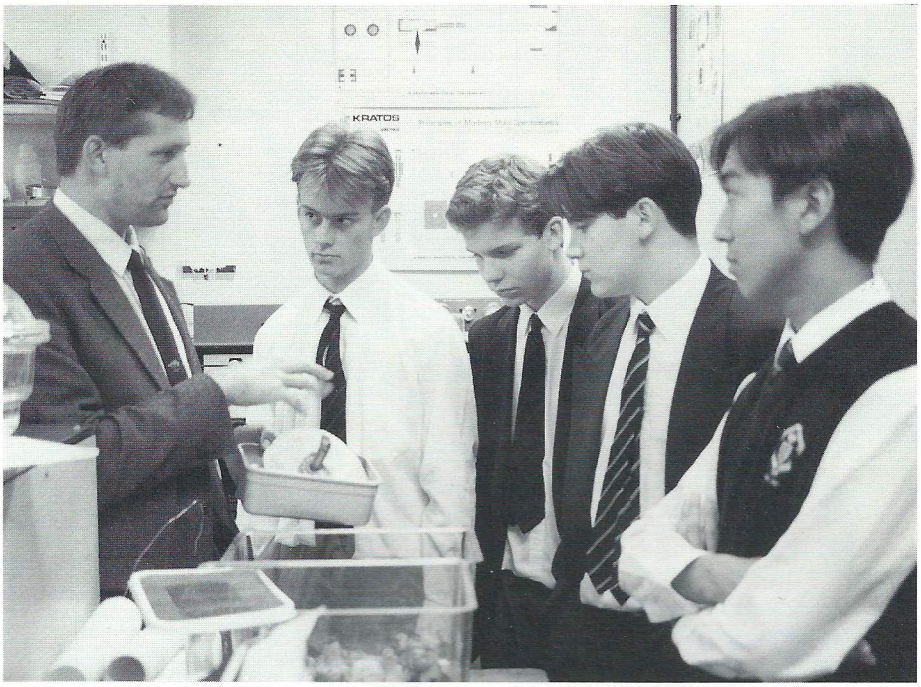


Scientist in Residence Stephen Natynczuk with pupils.

profound ignorance of science is socially acceptable, then we should examine our formative first experiences of science and technology. Education exists to unlock the imagination and creativity of all people, and nowhere is this more the case than in science.

Science is a way of thinking about and seeing the world available to everyone. It extends our humanity by making us aware of the unexpected intricacy and beauty of our existence while at the same time it provides us with the technology to influence our conditions in unimaginable ways.

But like much else, science can only really be understood by joining in; it gains its meaning through its use. By joining in, the young person learns the spirit of iconoclastic questioning which is at the heart of the best science, while realizing that there is more to science than isolated cerebral activity. To solve problems, he or she must to work with others; science is seen to be about people, is seen to be creative as well as analytical, and to have limitations as well as power. Such participation in genuine scientific exploration should be a central part of any real education in science.

Tracking black rats on Lundy cliffs with Paul Smith of King Edward's School, Birmingham.

Excellence in Science Exploration

What does this imply for excellence in science education? Of central importance is the need to create effective working interfaces between the world of the young person and the world of professional science and technology. Central also is the belief that we too often grossly underestimate the potential of young people of all abilities to contribute in and to gain from such encounters. I see this from the within my own experience.

When I entered teaching 12 years ago from a career in research, I was immediately struck by the artificial, isolated nature of much that was available in school science. I wanted to share, as many others have, something of the excitement of chasing the unknown, which is at the heart of science. The conventional isolated pursuit of examination success is much less inspiring, although a young person driven by an enthusiasm for exploration will do better here also in any sensible examination/assessment system, because he or she will in a much deeper way have a reason to learn and know the meaning of what is learnt.

I also found that many others were deeply concerned about the same issues, and were working both from within education and from outside to broaden horizons. The Association for Science Education – Royal Society Scientific Research in Schools Scheme, provides an important focus for this approach. This scheme exists to 'interest and excite pupils' scientific interest and to provide an opportunity for them to experience scientific research which is usually not feasible within the science curriculum'. Any science teacher may apply; the scheme provides expert advice, much encouragement and some funding.

Our first ASE – Royal Society study was in the area of my own academic research, and concerned the role of scent in the lives of animals. Through this experience I became aware of all the difficulties of school-based research at first hand, but also of the great rewards. The greatest was when we were invited to mount a display at the Royal Society Soirée in 1986. The pupils responded so well to this opportunity. Out of class, they organized themselves into research teams, achieved some extremely impressive results in the chemistry of scent and the behaviour patterns of animals, and at the Soirée itself, a representative group of pupils manned the exhibit with great confidence and authority. The key motivator was that they were being taken seriously as young scientists in the world beyond the school.

Ours was by no means a unique experience. Most years, a school research project is displayed at the Soirée beside the best that academia can offer. In 1992, this was a display by Dr Nigel Collins' pupils at King Charles I School, Kidderminster, in which they used artificial stream and pond systems to study the biology of freshwater invertebrates. Two years earlier Dr Francisca Wheeler's pupils from the Withington Girls' School, Manchester, had put on an enthralling display of their research on ice crystal formation in thunder clouds.

Rewarding as all this was and is, by the very scale of the effort involved it clearly is not the kind of enterprise which could easily be part of every school's experience of science, however much it should be, particularly for today's hard-pressed teachers. The question for me was how could this excellent experience become more widely available.

Girls are most often the most dedicated scientists.

The National Curriculum

There is much turmoil in education today but in spite of all the efforts, it is far from clear that the current prescriptive approach is breathing life into science education. Rather teachers are hard pressed and long for a period of stability in which they can do what they do best and what they really want to do, which is to inspire young people to grow to their full potential.

What really is excellent is that science is touching many more young people than ever before, and within the administrative tangle there are the seeds of many worthy ideas. Thus Attainment Target 1 of the National Curriculum for Science requires that:

'Pupils should develop the intellectual and practical skills that allow them to explore the world of science and to develop a fuller understanding of scientific phenomena, the nature of the theories explaining these and the procedures of scientific investigation.'

At the highest level, this requires the 16-year-old to plan and carry out an extended investigation involving a range of exploratory techniques with considerable depth of understanding.

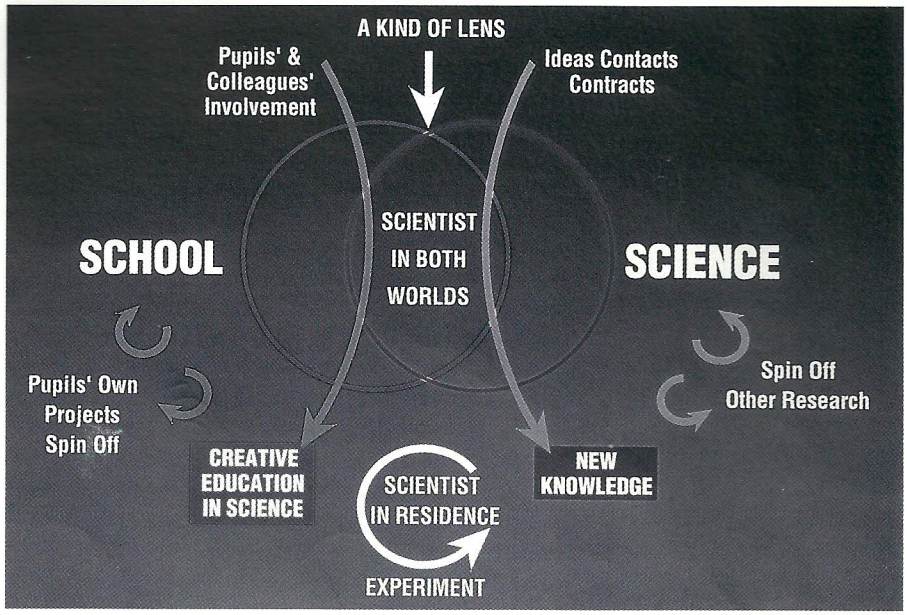
Excellent as this is, it is not new. In the last century, long before the National Curriculum had been dreamed of, some school teachers shared this vision. At Clifton College, the then Head of Science, William Shenstone, earned his FRS while teaching, and like his predecessor and colleague at Clifton, Sir William Tilden, he saw no rift between education and research. In his obituary of 1908 we read of him:

> 'He combined in a rare degree an ardour for research with skill in teaching . . . Nothing was more characteristic of him than his ceaseless and successful effort to advance knowledge, and his quick recognition of capacity for investigation in his pupils. He would let them see what he was aiming at and doing, invite their suggestions, give them some share in his work and sometimes, in papers communicated to scientific societies associate with his own name that of anyone who had assisted him . . . No man can stimulate original thought in others unless he is himself learning and making some advance.

Perhaps as the result of this spirit, three Clifton pupils of a later generation won Nobel prizes. But our concern, as is the concern of the National Curriculum, is not only with the stars, not that we really know who the stars will be, but with all young people; science is everyone's heritage.

Creative Partnerships

The key is to create and develop working interfaces between the world of the young person and the world of professional science and technology. There are already a number of excellent such initiatives. The ASE – Royal Society scheme is one; the British Association's CREST scheme is another. Other initiatives also encour-



The Scientist in Residence scheme increases the overlap between the world of school and the world of professional science.

We are currently planning a scientific expedition for young people to study the impact of irrigation on environment and society in the desert of Rajasthan.

age scientists and engineers to visit schools and young people and teachers to spend time in academic laboratories and industry.

The worlds of school and of professional science and technology are so very different that to achieve a really effective working interface, a deep knowledge of both worlds is essential. Within schools themselves, the principal limitations are:

- Lack of time of both pupils and staff.
- Low expectations of what is possible.
- Lack of space.
- Lack of funds, although sources do exist.
- Lack of expertise, although advice is available.

But in spite of the difficulties, the rewards for young people can be very great:

- It values scientific creativity and ingenuity; understanding science is more than learning facts.
- It values each person's contribution and enhances her/his scientific self confidence.
- Pupils learn at first hand both the nature of scientific exploration and how to access the scientific information they need as they need it. Disciplinary boundaries are seen in perspective.
- It links them with concerns which go beyond the confines of the school, and gives them a first hand appreciation of realities in the wider world. This is highly motivating.
- It promotes the idea that real science is a group activity and that the skills needed to work together effectively are essential. Intellectual skills are important but others are also.

In Bristol in 1988 we organized the first Research in Schools Workshop, to bring together some of the people promoting this kind of realism in school science. Our purpose was to encourage each other by seeing just what creative science and technology is currently being undertaken from many different school situations, to set up an informal network of contacts of teachers and others committed to promote such open-ended investigations, and to consider honestly through our own collective experience, the contribution that research in schools can really make in the light of the pressures and constraints that surround schools today. What was truly amazing was the range and the quality of the work which was quietly taking place in many diverse schools across the country.

We ran a second workshop in Bristol in 1990, with similarly encouraging results, and this autumn the Wellcome Trust is sponsoring a third more substantial workshop 'Experiments in Education, Pupils as Scientists', at the Wellcome Centre for Medical Science in London.

Scientists in Residence

My own response to exploring the interface between the world of school and the world of professional science was to experiment with the concept of a school-based 'Scientist in Residence'. This required no great imagination, for 'artists in residence' and the like were old hat. What was remarkable is that this appeared never to have been tried before.

Having successfully obtained outside support for our Scientist in Residence experiment in 1987, we invited Dr Stephan Natynzcuk, a skilled zoologist who had just completed his doctorate at the Wildlife Conservation Research Unit at Oxford University to join us as Scientist in Residence at Clifton College.

We now know that in America the Illinois Mathematics and Science Academy at Aurora had established a Resident Scientist programme quite independently although a little later than us, and closely similar reasons. As Dr Ronald Pine, the Resident Scientist, wrote to me in 1991, 'My primary duties consist of conducting "my own" research, and thereby serving as a role model, undertaking joint research with the students, and advising on the conduct of the research projects they are involved in, but in which I am not taking an active role. To the best of my knowledge, I am the only full-time researcher in the natural sciences employed at a secondary school anywhere in the Western Hemisphere.'

In Bristol, we soon learnt that the investigation should be real, not a simulation and not a game in which someone has 'the right answer' in an envelope. It generates and depends on partnerships between pupils, between pupils and teachers and between schools and professional science.

The following are among our projects.

- At the invitation of Professor Colin Besant, Professor of Computer Aided Manufacture at Imperial College, our pupils contributed to a major new research project on the use of robotics to aid surgeons in spinal operations. The problems were formidable and well beyond what a sixth-former would expect to encounter, but Professor Besant outlined the problem he faced and asked the pupils to devise their own pilot studies and suggest ideas how he might proceed. Within a year a representative group of pupils had given a paper on the subject at a medical conference in Bristol. Not only were their audience surprised

to hear sixth form pupils talking authoritatively and imaginatively on this subject, the pupils themselves were even more surprised, and all was achieved outside normal class time.

• We have worked with Dick Berry, Deputy Head of the Florence Brown Special School in Knowle, Bristol, in developing an applied research project with his Year 10 pupils investigating the mechanical properties of various concrete mixes. These are then used to manufacture items of garden furniture for sale on behalf of the school's camp fund. This study has generated vast enthusiasm among the pupils who recently won the Paul Dirac Science Prize for their work, and it certainly put to flight the rumour that science is only of interest to an academic minority! Mr Rowland Morgan, a civil engineer for Bristol University who is thrilled to be advising the study rightly wonders why this kind of work is not going on in every school.

• We see science-based expeditions as activities where young people can experience science as a part of life together in community. We are currently working jointly with the Indo–British Education and Exploration Trust and with the Youth Exploration Society of India on an scientific expedition for young people to the desert of Rajasthan in north-west India. Young people from both India and Britain will be working jointly with scientists at the Central Arid Zone Research Institute in Jodhpur, and will come into very close contact with the people of the desert, contributing to our understanding of the impact of irrigation on the life style and nutrition as well as on natural ecology.

• We also see scientific surveys as having a merit of their own. With the advice of Dr Linda Tyfield, a Clifton parent who runs a regional molecular genetics unit, we have helped our pupils devise a questionnaire which assesses the level of knowledge of inherited disease, and specifically of cystic fibrosis, and the contribution that genetic screening can make to its alleviation. As well as stimulating pupils to think both about scientific and about ethical issues, it is a sparked a great deal of discussion within the school about this disease; again at different levels pupil research is an immense motivator. Pupils have again been involved in presenting findings to outside audiences. A parallel study is now being undertaken by pupils at Badminton School, and this time parents are also being asked to take part.

• Within one of Clifton's girls' boarding houses, pupils have been organizing their own study of the menstrual synchrony which occurs in communities of women. For more than a year, some sixty teenage girls have been gathering their own data with a view to investigating the origin of this little studied phenomenon. Again, in the process, the girls were forced to think through not only scientific issues, but how ethically to mount such a study. The outcome is the accumulation of some unique data which, when analysed, will shed important light on the origin of this little-studied phenomenon. The study depends on the girls' own enthusiasm and commitment, and has been stimulated greatly by the interest both of Miriam Rothschild and also of Dr Cynthia Graham of the MRC Reproductive Biology Unit in Edinburgh.

• There is also international interest in this work. We are developing partnerships with Japanese science educators who are increasingly concerned to stimulate scientific creativity in their own young people. There is scope for genuine collaboration in this area while at the same time using science as a medium through which young people in each country can learn something of the attitudes of another culture.

Future Developments

We have now set up a new organization, the Clifton Scientific Trust with a view to developing this approach further. Clifton Scientific has just received funding from the Nuffield Foundation and the Salters' Company to begin this work.

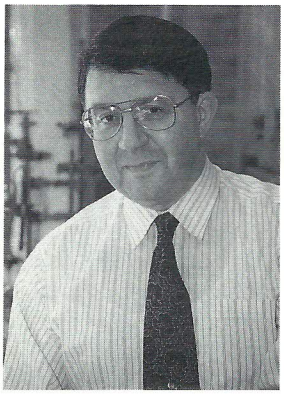
• We propose to build on our Scientist in Residence experience and promote working partnerships between the world of school and the world of professional science and technology.

• Through publications, workshops and consultation, we wish to share our practical insights and expertise with others working to build bridges between education and professional science and technology.

• We plan to monitor the progress of such school–professional science partnerships in order to build up an authoritative body of knowledge not only of effective strategies but of the educational and scientific outcomes of such strategies.

Throughout, we remain very aware of the implications of this work for wider questions of the public understanding of science.

Finally, I would like to give due credit to my close colleague, Dr Stephan Natynczuk (see 'Confessions of a live-in scientist', *New Scientist*, 30 November 1991), who has shared with me many of the experiences related here. ■



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