PUTTING HISTORY IN SCIENCE: RESOURCES FOR TEACHING HISTORY OF SCIENCE COMPONENT OF SCIENCE COURSES IN SCHOOLS IN THE UNITED KINGDOM
Conferència de cloenda

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The coming of the national curriculum

Probably the biggest change in education in England in the last generation occurred in 1989. This was the year that the Conservative government introduced the National Curriculum. For the first time all pupils aged 5 to 16 were to receive education in the same set of subjects each with its prescribed content. The introduction of the National Curriculum caused a revolution in science teaching. Not only were all pupils in primary (ages 5 to 11) and secondary (ages 11 to 16) schools to be taught science but the content of every course for the whole age group was tightly defined for the first time. All pupils in state funded schools would receive a science education that covered biology, chemistry and physics as well as the techniques of scientific investigation. This was a big change, as up to this time provision of science teaching in primary schools was inconsistent and sometimes non-existent, some secondary pupils opted out of science completely and many opted for a restricted science programme that left out one or more of the scientific areas (for example many girls studied biology but not physics).

The National Curriculum for Science (1989) divided the content of science courses into 17 topics, or "Attainment Targets" as they were called in the new language. These would be taught throughout the four "Key Stages" of education.

TABLE 1. Age groups covered by each Key Stage in the English National Curriculum

Key Stage	*Year groups*	*Pupils' ages*
1	1,2	5 - 7
2	3,4,5,6	7 - 11
3	7,8,9	11 - 14
4	10,11	14 - 16

Attainment Target 1, Exploration of Science dealt with the techniques and skills of carrying out scientific investigations. ATs 2 to 16 covered the content of a science course and AT 17 was The Nature of Science. Unlike most of the other ATs the Nature of Science only applied to the last two Key Stages, generally taught in secondary schools.

The Programme of Study summarised what pupils should study in AT 17. At Key Stage 3 it said:

> Through their own investigations and the use of text, film, other secondary sources and case studies, for example focused on the life and work of famous scientists and/or the development of an important idea in science, pupils should be given opportunities to:
>
> - Study the ideas and theories used in other times to explain natural phenomena.
> - Relate such ideas and theories to present scientific and technological understanding and knowledge.
> - Compare such ideas and theories with their own emerging understanding and relate them to available evidence. (Department of Education, 1989)

At Key Stage 4 the Programme of Study added:

> (Pupils) should also:
>
> - Distinguish between claims and arguments based on scientific considerations and those which are not.
> - Consider how the development of a particular scientific idea or theory relates to its historical and cultural – including the spiritual and moral – context.
> - Study examples of controversies and the ways in which scientific ideas have changed. (Department of Education, 1989)

The Attainment Targets gave more detail about what pupils of different abilities and at different times in their education may be expected to be capable of. For example, at level 4, the lowest level of attainment at Key Stage 3,

> Pupils should:
>
> - Be able to give an account of some scientific advance, for example, in the context of medicine, agriculture or engineering, describing the new ideas and investigation or invention and the life and times of the principal scientist. (Department of Education, 1989)

While at level 10, the top level at Key Stage 4, achieved by bright 16 year olds,

> Pupils should:
>
> - Be able to demonstrate an understanding of the differences in scientific opinion on some topic, either from the past or present, drawn from studying the relevant literature, for example, plate tectonics and the wrinkling of a shrinking Earth OR living things reproduce their own kind and the spontaneous generation of species.

- Be able to relate differences of scientific opinion to the uncertain nature of scientific evidence, for example, what is the cause of 'cot deaths', OR what is responsible for the death of trees in European forests. (Department of Education, 1989)

It was apparent that while AT17 the Nature of Science was concerned with the processes of and contemporary issues in science it was also very much about the history of science. The publication of the National Curriculum for science caused panic in some teachers and agitation in many. For the first time knowledge and understanding of some history of science would be assessed in public exams.

The National Curriculum for Science came into force in August 1989. Pupils aged 11 entering year 7, the first year of the Key Stage would be the guinea pigs. In 1992 they would be the first to be assessed in the statutory tests at the end of Key Stage 3 and in 1994 they would be the first to sit the public examinations known as the General Certificate of Secondary Education (GCSE) based on the National Curriculum.

Answering the call

Prior to the arrival of the AT17 the use of history of science in science teaching had been very patchy. Up to the 1970s many teachers had made use of historical anecdotes and these were also a feature of the textbooks of the time. In the 1970s and early 1980s textbooks changed (Ellis, 1982). On the one hand they became more colourful but on the other hand they lost their narrative style. Scientific process was in, while quaint stories of heroes went out. Trendy science teachers adopted teaching methods that frowned on the teacher standing at the front of the class telling anecdotes. History of science largely disappeared from science courses.

AT17 demanded a new look at science teaching and new resources were called for. The major education publishers rubbed their hands with glee as they set about providing books and courses for the new curriculum. Some merged the Nature of Science material with the other ATs while other publishers delivered a book for each AT. The author was involved with one such project launched by the famous old name in educational publishing, Basil Blackwell. Two books on the Nature of Science were produced, *What is Science?* for KS3 (Ellis, 1990) and *Science Changes!* for KS4 (Ellis, 1992). These books delivered the requirements of AT17 in a colourful and readable manner.

The Association for Science Education (ASE) lead the way in providing resources. The *Nature of Science* series of booklets edited by Prof. Joan Solomon, such as *Louis Pasteur* (Kingsley, 1989). Each topic was covered in a readable, well-illustrated, small format, 40 page booklet.

Teachers began to teach Nature of Science to KS3 pupils and looked ahead with some trepidation to the introduction of the National Curriculum at KS4. But the curriculum was not set in stone.

Revise, revise, revise

Worries about the complicated structure of the National Curriculum for Science and the difficulty of assessing all the Attainment Targets had surfaced as soon as the docu-

ment was published. By 1991 the worries had reached the highest level of government. Quite abruptly in 1992 a revision to the National Curriculum was announced. The 17 attainment targets were reduced to 4 and the Nature of Science disappeared from the assessed part of the document. Teachers breathed a sigh of relief and publishers cursed as their new series, now hitting the marketplace, were rendered instantly obsolete. While Key Stage 3 pupils had been introduced to history of science as part of AT17, the revision occurred before Key Stage 4 pupils met the topic.

Another revision occurred in 1995. There were still four ATs but the content had been pared down so that it would fit into the time allowed for teaching. Nature of Science was still not explicitly examined but did appear in the introduction to the Programme of Study in what became known as Science Attainment Target 0 (Sc0). At Key Stage 3, Sc0 stated:

> Pupils should be given opportunities to:
>
> 3c Relate social and historical contexts to scientific ideas by studying how at least one scientific idea has changed over time. (Department for Education, 1995)

while the Sc0 statements at KS4 included:

> Pupils should be given opportunities to:
>
> 3a Develop their understanding of how scientific ideas are accepted and rejected on the basis of empirical evidence and how scientific controversies can arise from different ways of interpreting such evidence.
> 3b Consider ways in which scientific ideas may be affected by the social and historical contexts in which they develop and how these contexts may affect whether or not the ideas are accepted. (Department for Education, 1995).

While these statements gave advocates of the history of science hope, the truth is that most teachers ignored the non-assessed parts of the National Curriculum including the nature of science. The textbooks of the late 1990s did however begin to include snippets of history. However the relevance to the teaching was not always clear, as James Williams commented:

> - The history of science is often included as a non-essential 'add-on' and serves little purpose in developing ideas and/or concepts.
> - The figures mentioned and elaborated upon are mostly those that have traditionally been used e.g. Newton, Einstein, Darwin, Mendeleeff, etc.
> - There is little or no attention paid to the context within which the science was developed.
> - Few accounts of the lives of scientists are given or how they worked.
> - Some information is factually incorrect. (Williams, 2002)

Nevertheless there was a growing sense that the nature of science should make more of a contribution to science teaching. The opportunity came with the next revision of the Na-

tional Curriculum in 1999. This cut back yet again the still heavy load of knowledge and understanding required of pupils but more important was an addition to the first Attainment Target Scientific Enquiry. This was a section headed "Ideas and Evidence in Science". Unlike the lamented AT17, Ideas and Evidence was to be part of science teaching from Key Stage 1. While many of the statements can be seen to be concerned with contemporary issues, there is clear and explicit reference to historical material. For instance at KS2:

> Pupils should be taught:
>
> (a) That science is about thinking creatively to try to explain how living and non-living things work and to establish links between causes and effects (for example Jenner's vaccination work). (Department for Education, 1999)

at KS3:

> Pupils should be taught:
>
> (a) About the interplay between empirical questions, evidence, and scientific explanations using historical and contemporary examples (for example Lavoisier's work on burning, the possible causes of global warming).
> (b) That it is important to test explanations by using them to make predictions and by seeing if evidence matches the predictions.
> (c) About the ways in which scientists work today and how they worked in the past, including the roles of experimentation, evidence and creative thought in the development of scientific ideas. (Department for Education, 1999)

and at KS4:

> Pupils should be taught:
>
> (a) How scientific ideas are presented, evaluated and disseminated (for example by publication, review by other scientists).
> (b) How scientific controversies can arise from different ways of interpreting empirical evidence (for example, Darwin's theory of evolution).
> (c) Ways in which scientific work may be affected by the contexts in which it takes place (for example, social, historical, moral, spiritual) and how these contexts may affect whether or not ideas are accepted.
> (d) To consider the power and limitations of science in addressing industrial, social and environmental questions, including the kinds of questions science can and cannot answer, uncertainties in scientific knowledge, and the ethical issues involved. (Department for Education, 1999)

Ideas and Evidence was met with a warmer response by science teachers. Teaching of the new version of the National Curriculum commenced at KS3 in 1999 and at KS4 in 2001. Once again the publishers began to prepare publications to reflect the new requirements.

Teaching at Key Stage 3 has been guided by two further official pronouncements. In 2000 the Qualifications and Curriculum Authority (QCA), the government organisation that supervises the implementation of the National Curriculum, published its scheme of work for science at KS3. This provides a detailed teaching programme for the whole three years of the Key Stage in 36 units. Many schools have adopted the scheme and published courses follow the unit format. There are a considerable number of historical references in the QCA Scheme of Work, for example in unit 7A (the first):

> Possible Teaching Activities
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> Show pupils evidence of the early observations made by Robert Hooke and others to illustrate how the development of the microscope changed the way in which scientists viewed the structure of living things. Ask pupils to find out how ideas developed. (Website 1)

In the last year another file landed on teachers' desks called the Key Stage 3 National Strategy Framework for Teaching Science: Years 7, 8 and 9. This document was produced by the Department for Education and Skills, the same government department that introduced the National Curriculum. The Framework document nevertheless, seems to be at odds with the National Curriculum by suggesting six teaching themes – Scientific Enquiry, Cells, Interdependence, Particles, Forces and Energy – each with a new set of statements prescribing what pupils should be taught in each of the years. Neglecting the other queries the Framework raises, we do however find history of science in the first of the themes. For example:

> Year 7 pupils should be taught to:
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> • Consider early scientific ideas, including how experimental evidence and creative thinking have been combined to provide scientific explanations.
>
> Year 8 pupils should be taught to:
>
> • Consider how some early scientific ideas do not match present-day evidence and describe how new creative thinking has been used to provide a scientific explanation.
>
> Year 9 pupils should be taught to:
>
> • Explain how scientific ideas have changed over time; describe some of the positive and negative effects of scientific and technological developments. (Department for Education, 2002)

There is no doubt that with these three documents – the Curriculum, the Scheme of Work and the Framework – teachers are left in no doubt that history of science plays some part in teaching science – at least at KS3.

At KS4 the picture is less clear. The 3 awarding bodies (what used to be called examining boards) decided that Ideas and Evidence should contribute just 5% to every science qualification at GCSE. They also decided that, although part of the Scientific Enquiry Attainment Target normally assessed through coursework marked by teachers, Ideas and Evidence should

be examined in the written papers set at the end of the course in year 11. Thus in June 2003 the first cohort of pupils met questions on Ideas and Evidence in their science examinations. Unfortunately the awarding bodies have largely treated Ideas and Evidence as a small and trivial addition to the main job of assessing recall and understanding. The questions provided in sample papers were not encouraging. As Peter Fowler in his comments on a question on Darwin noted:

> […] this question uses History of Science as the context and relies on comprehension and/or factual recall of only science content. No History of Science content or skills are being assessed. This falls far short of the potential expounded in Sc1 of the NC. Therefore this question shows a gap between what could be assessed in History of Science and what is actually tested. This applies to the majority of the other questions in the Edexel specimen questions [...]. (Fowler, 2003)

The actual exams in the summer of 2003 dashed many hopes for a proper assessment of the history of science. One example from a higher level Physics paper asked:

> In 1915 the scientist Alfred Wegener suggested that Africa and South America had once been joined but had since drifted apart. Evidence for his theory came from the animal fossils found in the two continents. The fossils are almost the same although animals now living in Africa and South America are different. Other scientists did not agree with Wegener and suggested that a land bridge had once joined the two continents.
>
> [map showing hypothetical land bridge between South America and Africa]
>
> How could scientists use the idea of a land bridge to explain the evidence put forward by Wegener? (2 marks) (GSCE Pyshics, 2003)

It is difficult to see how this question assesses pupils' ability in any of the four Ideas and Evidence statements. Unfortunately it is not an odd example. The fear is that if the quality of questions does not improve teachers will come to consider Ideas and Evidence a trivial and unnecessary part of their courses.

More hopeful is a completely new GCSE course devised by the Nuffield Curriculum Centre and the University of York Science Education Group. The course known as 21st Century Science takes a completely new approach to science education and aims to cater for all pupils in particular those not planning on taking their science studies further than Key Stage 4. 21st Century Science places Ideas About Science central to the teaching of the core units, and there is plenty of opportunity to bring historical issues into the teaching (Website-2). QCA has given considerable support to 21st Century Science which may become the model for the next revision of the National Curriculum.

Successes and failures

The National Curriculum has had is successes and failures. All pupils from ages 5 to 16 are now being taught science in England and Wales. The quality of science teaching in

primary schools has improved. However despite government initiatives and a dedicated band of science teachers, the number of pupils studying science after the age of 16 has remained static. The National Curriculum has evidently failed to convince more students that science is exciting or a rewarding career.

The first pupils to follow the National Curriculum are now in their mid twenties but there is little evidence that their experience of science has given them greater knowledge of or a more positive attitude to science.

It is difficult to estimate how much history of science is being taught in English schools. A teacher's perception of the importance of the historical element in their chosen course will determine how much history of science pupils actually. Like other aspects of science teaching the pupils experience depends on their teachers' enthusiasms despite the strictures of the National Curriculum. Nevertheless the author's perceives that more is happening and that some teachers are being innovative in their use of the history of science. The textbooks and published courses that are arriving on the market now include activities based on the history of science. Many of these will be traditional comprehension style questions and answers, but some provide other ways of introducing the history of science, such as:

- Drama – scripted or improvised playlets allow pupils to visualise historical events.
- Role play debates – pupils take on historical or contemporary roles to debate an issue in science.
- Discussion – pupils are given background information and data to argue about a controversy in science.
- Reconstruction – pupils perform experiments based on historical work perhaps comparing two different approaches to investigating a problem.
- Multimedia presentations – pupils research about a scientist or controversy and produce a presentation or magazine style report on their findings.

These activities have the potential to develop important skills as well as introducing pupils to a wide variety of scientists and ideas.

Resourcing the history of science

In the late 1990s the ASE was again a leader in producing resources for the history of science, with a series of photocopiable packages celebrating the important centenaries – X rays in 1995, Radioactivity in 1996, the Electron in 1997 and Radium and Radiochemistry in 1998. These were packed with information and activities and proved popular.

In January 1999 the author commenced publication of a resource pack, called "breakthrough". This consisted of photocopiable resources on a wide variety of topics that took the history of science from ancient times to the present day with interviews with practising scientists. The packs were relatively popular and nine were produced in a period of three years. The time consuming and expensive business of advertising and marketing eventually persuaded the author to leave the business of publishing to the established companies. By this time most publishers were including material for Ideas and Evidence in their text-

books or providing additional resources. One such was the Science Web Readers produced by NelsonThornes and edited by Joan Solomon. These were part of an innovative course for Key Stage 3. The three books, (in biology, chemistry and physics) provided pupils with articles about science and scientists that provided background and history to topics in the science curriculum. The books were stimulating although the length of the articles and language level may have been too much for 11 year olds.

In 2002 NelsonThornes extended the principle to Key Stage 4 with a further set of three books titled *Readings in Science* (Ellis; Ryan; MacDonald, 2003). These have been given a lighter magazine-like style but again extend pupils into areas beyond the normal curriculum including historical topics.

People in science

Probably the most innovative resource for teaching science through its history and characters is the *People in Science* series produced jointly by Pearson and Immersive Education (Ellis, 2003). *People in Science* is an interactive computer programme available on CD-ROM. Each pack consists of a number of elements. First there is a set of images of historical and contemporary figures in six topic areas. Each figure can be rotated and given different poses and scale. Then there is a set of appropriate environments or backdrops in which the characters can be placed. Next there are props which can also be rotated and sized. The author was responsible for writing the text for the discs. This consists of a monologue for each character describing their life and their ideas. The monologue can be accessed on screen or as audio files read by actors. There are other features which add to the excitement of the resource. A teachers' guide and on screen activities direct students to manipulate the graphics and the text to answer questions about scientific concepts, the contribution of the characters and the development of ideas. Most activities involve pupils adding to or developing storyboards – a series of images utilising the characters, environments, props, text and special effects.

The software lends itself to a variety of learning activities including:

- Providing characters with speech but blank thought bubbles for students to complete.
- Giving speech bubbles but no character, students are asked to add the correct speaker.
- Filling in blanks in speeches or captions.
- Finishing a storyboard about an event or development of a theory.
- Filling in missing stages in storyboard.
- Adding missing details.
- Correcting erroneous details.
- Simulating a debate between characters.
- Turning a storyboard into a presentation.

But describing *People in Science* does not do it justice. Seeing the programme working, trying it out for oneself or experiencing pupils begin to use it five minutes after meeting it for the first time, are the best ways to discover its worth as an educational resource.

It remains to be seen whether *People in Science* and the other resources becoming available will help students gain an appreciation of the history of science and hence achieve a better understanding of how science works and influences the world.

Bibliography

DEPARTMENT FOR EDUCATION (1995). *The National Curriculum*, HMSO.

DEPARTMENT FOR EDUCATION & EMPLOYMENT/QUALIFICATIONS & CURRICULUM AUTHORITY (1999). *The National Curriculum for England: Science*, HMSO.

DEPARTMENT FOR EDUCATION & SKILLS (2002). *Key Stage 3 National Strategy Framework for teaching science: Years 7, 8 and 9*, HMSO.

DEPARTMENT FOR EDUCATION & SCIENCE AND THE WELSH OFFICE (1989). *Science in the National Curriculum*, HMSO.

ELLIS, P. R. (1982). *The history of science and the teaching of chemistry*, Unpublished M. Phil. thesis, University of East Anglia.

ELLIS, P. R. (1990). *What is Science?*, Oxford, Basil Blackwell.

ELLIS, P. R. (1992). *Science Changes!* Hemel Hempstead, Simon & Schuster Education.

ELLIS, P. R.; RYAN, L.; MACDONALD, A. (2003). *Readings in Science: Biology* (Peter Ellis), *Chemistry* (Lawrie Ryan), *Physics* (Averil MacDonald), NelsonThornes.

ELLIS, P. R. (2003). *People in Science*: *Elements & Atoms*, *Evolution & Genetics*, *Earth & Universe*, *Health & Disease*, *Electricity & Force*, *Earth & Environment*, Essex/Oxford, Pearson/Immersive Education.

FOWLER, P. (2003). «Assessment of the History of Science: Edexel GCSE specimen papers», *Education Forum, The newsletter for the Education Section of the BSHS*, 40, 1-5.

GCSE PHYSICS HIGHER TIER (2003). *Assessment and Qualifications Alliance*, Paper 3451/H.

KINGSLEY, N. (1989). *The Nature of Science - Louis Pasteur*, College Lane, Hatfield, The Association for Science Education.

WILLIAMS, J. D. (2002). «Ideas and evidence in science: the portrayal of scientists in GCSE textbooks», *School Science Review December*, (84), 307.

Websites

1. Schemes of Work for KS3 Science: <http://www.standards.dfee.gov.uk/schemes2/secondary_science/?view=get>.

2. 21st Century Science: <http://www.21stcenturyscience.org/home/>.