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Twenty First Century Science

implementing a school science curriculum with choice for all

Overview

- Why change?
- Clarifying ‘scientific literacy’
- Designing *Twenty First Century Science* (C21)
- Assessing scientific literacy
- Outcomes

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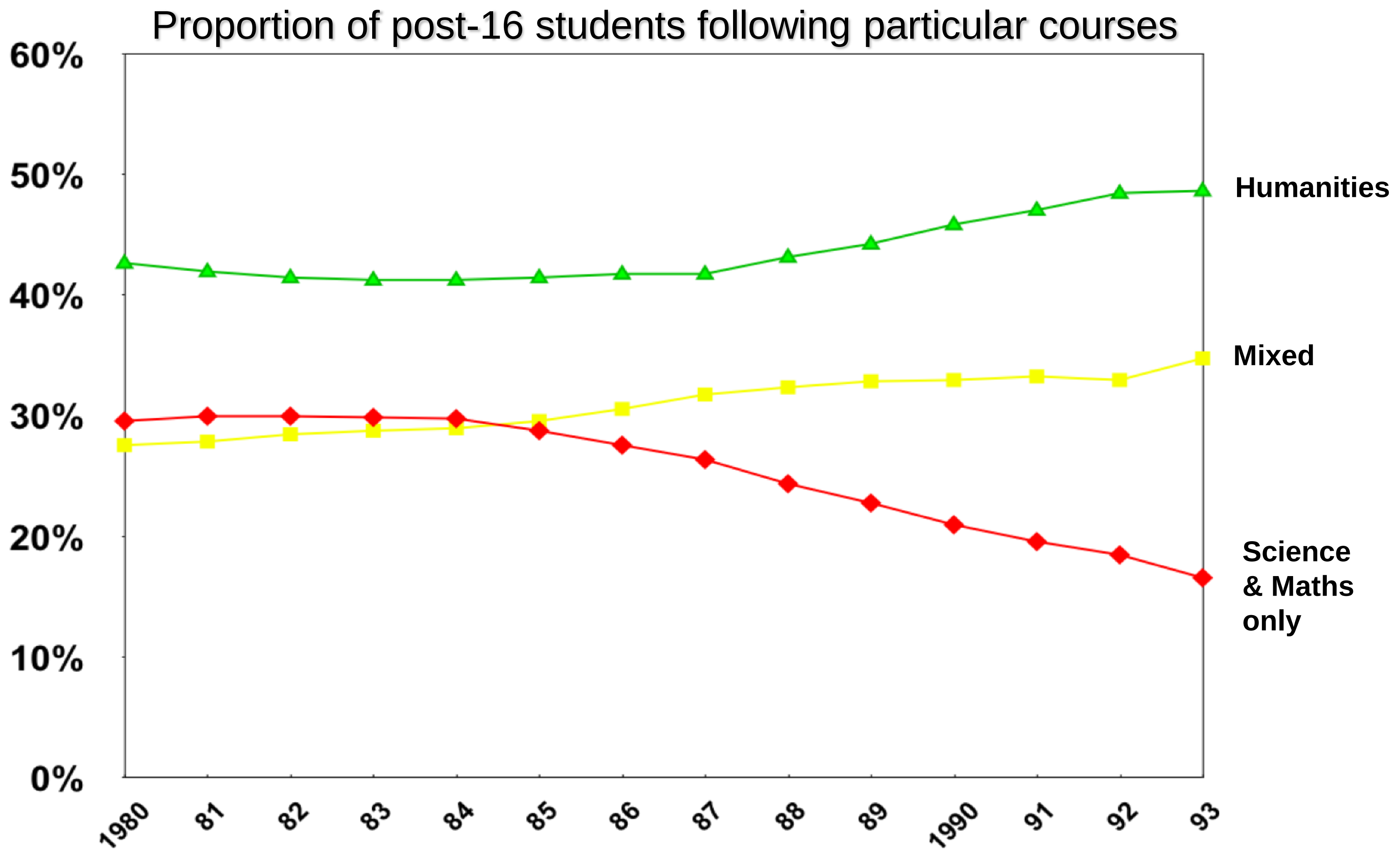
Why change?



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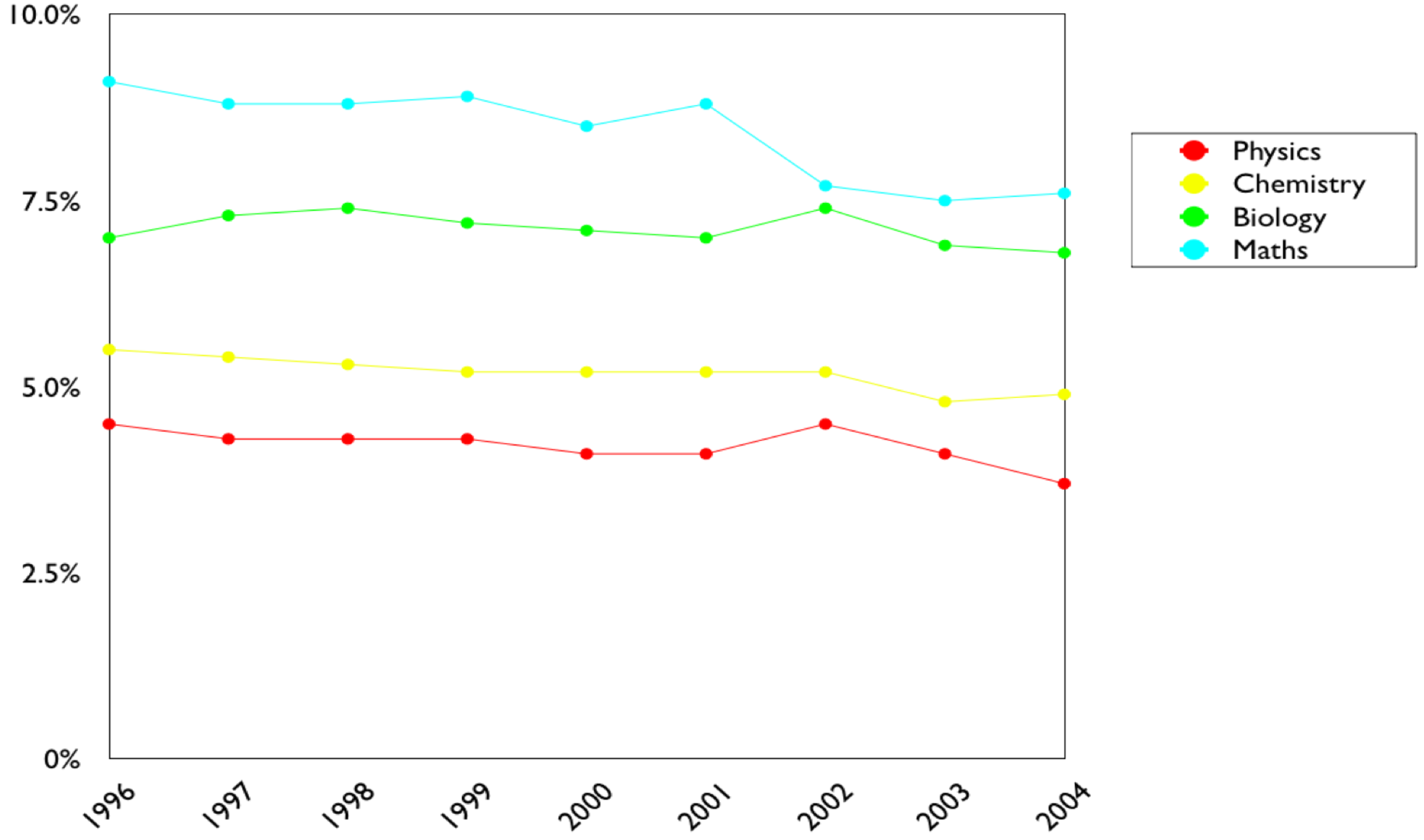
Proportion of post-16 students following STEM courses



- “respondents were concerned that pupils… were not enthused by the content of the science curriculum
- … could not relate the issues they studied in science to the world around them.
- All these issues … were seen to result in declining numbers taking mathematics, physics and chemistry at A-level and beyond.”

(Sir Gareth Roberts’ Review (2002) SET for Success: The supply of people with science, technology, engineering and mathematics skills)

Previous curriculum (age 14-16)

- Double Award GCSE Science
  - Broad, balanced curriculum (B, C, P)
  - 20% curriculum time for two years
  - Counts as two subjects
  - Taken by most students (England and Wales)
- A minority study a reduced Single Award course
- A minority study three separate subjects (Biology, Chemistry, Physics)

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A key distinction

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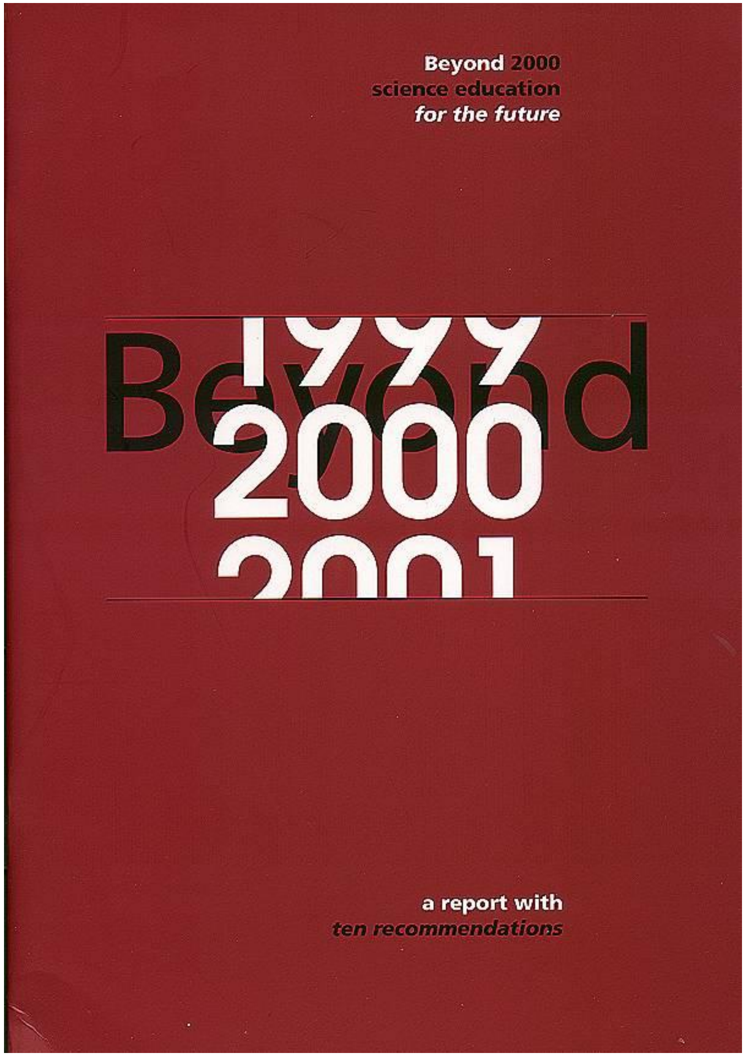
Science education should aim to improve the quality of this engagement.

The *Beyond 2000* report



- "The science curriculum from 5 to 16 should be seen primarily as a course to enhance general 'scientific literacy'."

Scientific literacy

For some:

"To speak of scientific literacy is simply to speak of science education itself."

(deBoer, 2000: 582)

A more common view:

"[Scientific literacy] stands for what the general public ought to know about science."

(Durant, 1993: 129)

A concern

But what about our future scientists?

A scientifically literate person can...

- read with understanding articles about science in the popular press

- engage in social conversation about the validity of the conclusions in such articles

- identify scientific issues underlying national and local decisions and express opinions that are scientifically and technologically informed

- evaluate the quality of scientific information on the basis of its source and the methods used to generate it

- pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately

(*National Science Education Standards* (NRC, 1996))

A starting point

The school science curriculum should provide:

- access to basic scientific literacy for all
- the first stages of a training in science for some

- Different kinds of science course are needed to do each of these well

Pilot curriculum model

GCSE Science	GCSE Additional Science
10% curriculum time	10% curriculum time
	or
Emphasis on scientific literacy	GCSE Additional Applied Science
(the science everyone needs to know)	10% curriculum time
for *all* students	for *many* students

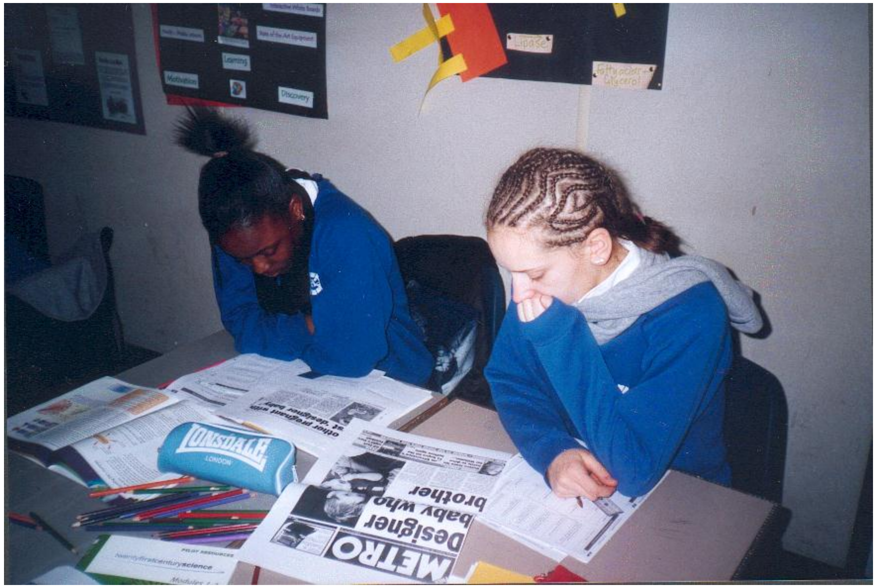
- Pilot trial in 78 schools from September 2003
- Supporting teaching materials from Twenty First Century Science project team

GCSE Science: a course for scientific literacy

Designing for scientific literacy

- The central aim:

  - to provide a ‘toolkit’ of ideas and skills that are useful for accessing, interpreting and responding to science, as we encounter it in everyday life



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What science do we meet everyday?

- a lot about health, medicine, environment
- risk and risk factors
- claims about correlations and causes
- issues that involve science and technology, but also involve other kinds of knowledge, and values

What do you need to deal with this?

- Some understanding of major scientific ideas and explanations

- Some understanding of *how science works:*
  - the methods and processes of scientific enquiry
  - the nature of scientific knowledge
  - the interface between science and society

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(Science Explanations)

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(Ideas about Science)

"If developing a scientifically literate populace, who will have the critical faculties to begin to assess the significance of scientific evidence and ideas, is to be an aim of science education, then teaching about the nature of science is not an indulgence but an essential act, fundamental to a contemporary science education."

[Osborne, J. (2002). In R. Boohan & S. Amos (eds). Aspects of Teaching Secondary Science. p. 237.]

Science Explanations

- Focus on the 'big ideas' of science
  - the idea of a 'chemical reaction' as a rearrangement of atoms; nothing created or destroyed
  - the gene theory of inheritance
  - the theory of continental drift

  and so on …

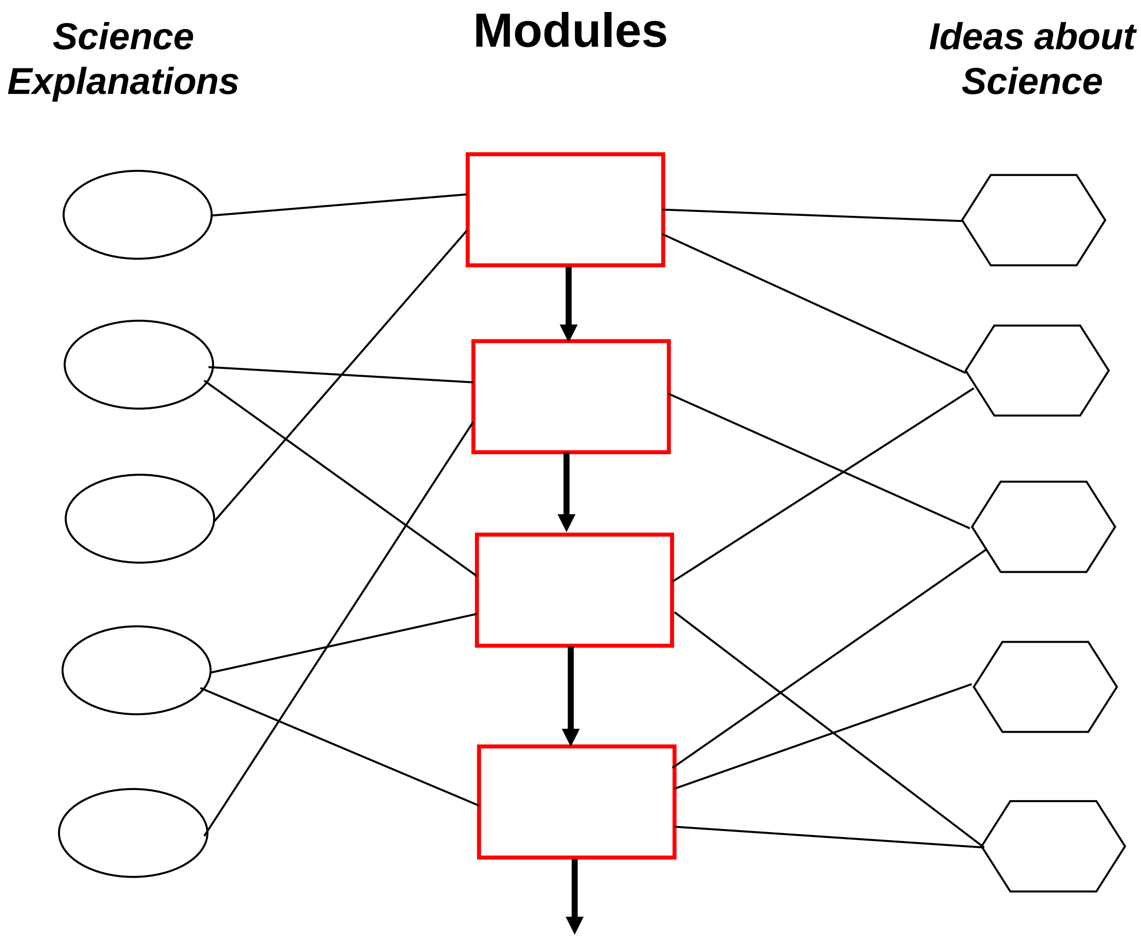
- Aim for a broad, qualitative understanding

- Depth of treatment: only as much as a non-scientist requires

Ideas about Science

- The importance of data ... and its limitations
- Patterns in data – correlation or cause?
- Developing explanations – how do we know what we know?
- Scientific community – role in producing reliable knowledge
- Risk and risk assessment
- Making decisions about applications of science

Course structure



Module titles

- You and your genes B
- Air quality C
- The Earth in the Universe P
- Keeping healthy B
- Material choices C
- Radiation and life P
- Life on Earth B
- Food matters C
- Radioactive materials P

Impact of scientific literacy aims

- Teaching of key Science Explanations (SEs) is focused on the big themes, with less emphasis on unnecessary detail
- Time is available for students to develop their knowledge of Ideas about Science (IaS)
- Time is freed up for students to discuss *and apply* concepts introduced in the course, developing skills of critical thinking, argumentation ...
- Small-group discussion work is particularly important
- Purpose of practical activities is to give students a “feel” for reliability of data

How is the course assessed?

- External assessment
  - Modular papers: Initially objective-style questions to assess SE and IaS
  - From 2010 these papers will use free-response questions to assess IaS
  - Terminal paper: based on a scientific report, holistic assessment of IaS, free-response questions
- Internal assessment of skills requiring knowledge of Ideas about Science
  - Data Analysis: interpretation and evaluation of first-hand data
  - Case Study: critical evaluation of evidence on both sides of a scientific question

Outcomes

- Evidence from the pilot:
  - internal evaluation – data from questionnaires completed by pilot teachers

Millar, R (2006). *Twenty First Century Science*: Insights from the development and implementation of a scientific literacy approach in school science. *International Journal of Science Education*, 28 (13), 1499-1522.

Is the Science course successful?

- Is the science course successful in improving students' scientific literacy?

  - Clearly having an affect. Pupils discussing issues from experience, issues from news, from magazines, both in and out of lessons.

  - Very successful with most students. Students are prepared to discuss a topic, questions ideas and listen to others. Been evidence both verbally and in written work.

  - Students were amazed at first to be asked their opinions on topics. Now they are much more knowledgeable about current scientific issues and willing to express concerns, opinions.

Coding of open responses	*Number of teachers*
Very successful	9
Successful	26
Neutral	2
Unsuccessful	1
Very unsuccessful	2

Some problems identified

- Literacy access too high. Often poor pupils would be disengaged...
- Generally the vocabulary was difficult for the average student and almost impossible for the less able.
- The lack of practical activities led to pupils being ‘turned off’.

Is the Science course different?

- Yes. Far more group work and emphasis on views of students. More discussion work done.
- Very much so. Teaching styles adopted are more inclusive, so focus in on where science impacts human activity, and not study topics isolated from students' experience.
- One student who was asked the question said that it was different because the science he was learning actually mattered.

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Coding of open responses	*Number of teachers*
Very different	20
Different	19
Not much difference	1

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How are students responding?

- Students are generally more interested in science as they can see the relevance.
- More interest in science issues and will often comment on stories in the media.
- Mixed. A* to C more engaged. D to G have found it difficult.
- Very pleased with the engagement of all abilities of pupils with ethical issues such as ... cloning.
- Less able really engaged, in many cases has really gripped their imagination.

End of pilot year one:

Coding of open responses	*Number of teachers*
Much better	6
Better	21
Same	7
Worse	4
Much worse	1

Positives identified by teachers

- Everyday relevance of content, up to date, links to science in media
- Opportunities to discuss and debate, develops critical thinking
- Inclusion of ethical issues, links to citizenship
- Less emphasis on factual content, more emphasis on IaS
- Range of learning styles and skills required, encourages independent learning (Case Study assessment activity)

Challenges identified by teachers

- Amount of reading and language demand of resources, especially for weaker students
- Activities which require students to reason and debate are challenging for many
- Managing discussion activities in class
- Finding your way around new specifications and resources – recognising what is essential
- Teaching IaS is new for us

Response to pilot feedback

- Worked with pilot schools to:
  - develop new or alternative materials for some activities with lower reading demand
  - added more practical activities to some modules
- Built reflection on purpose of practical work into training
- Built small-group discussion pedagogy into training

Early external evaluation of pilot

Three studies:

- Student learning compared with other science courses
- Students' attitudes towards science and school science
- Teachers' and students' views of the scientific literacy course, and its classroom implementation

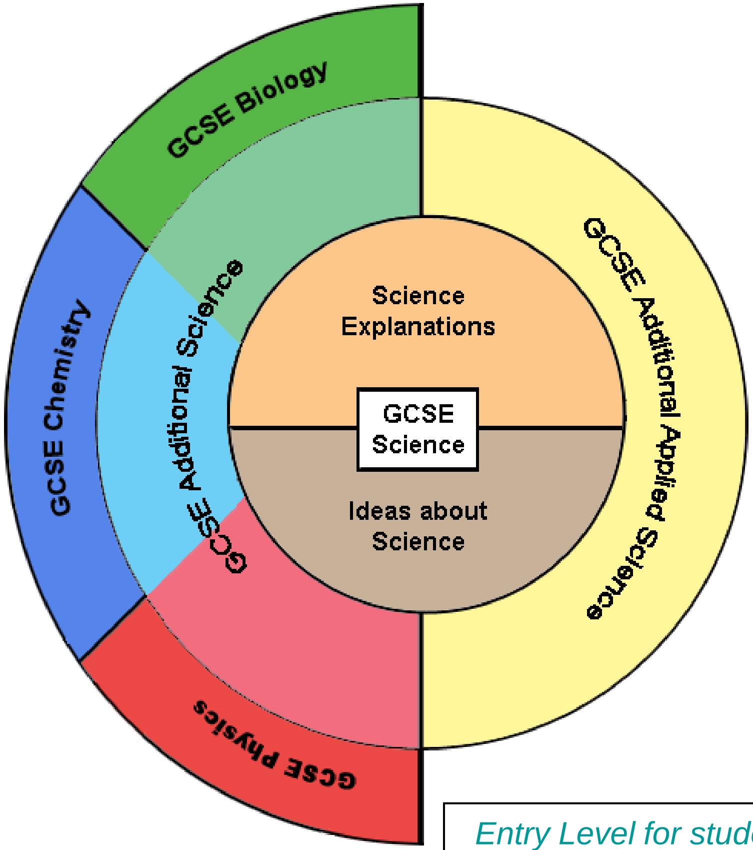
- http://www.21stcenturyscience.org

  (go to 'Rationale' then 'Evaluation')

External findings of pilot

- Generally positive teacher and student response
- Improvements in students’ interest in reading about science
- Level of conceptual understanding similar to more ‘traditional’ courses
- Teachers need continuing support and training to improve understanding of course aims, and confidence with the new teaching styles involved

Post-pilot: a revised suite



Entry Level for students working towards GCSE Science

Post-pilot: UK national curriculum

- UK National Curriculum for students aged 14-16 changed from September 2006 onwards
- Increased emphasis on nature of science in the core curriculum, and flexible options for other courses
- From September 2008 National Curriculum for students aged 11-14 also has increased emphasis on nature of science

C21 uptake from September 2006

- Around 1000 schools (~25% of maintained schools in England) have chosen *Twenty First Century Science*

  - One of five suites of specifications for ages 14-16 on offer

  - Generally seen as the most innovative

Since pilot & ongoing

Working with teacher groups to:

- produce ‘Stepping Stones’ to Ideas about Science
- integrate Assessment for Learning (AfL) into teaching schemes
  - ‘student-speak’ versions of IaS as criteria to judge progress
  - developing trialled AfL activities for each module

- produce assessment questions for flexible use in the classroom

What have we learned?

- A better understanding of the curriculum implications of 'scientific literacy'
  - We learn by trying to put our ideas into practice
- How to bring the 'nature of science' into the science curriculum
  - Not as a separate element, but integrated with science content
- That many teachers and students respond very positively to a 'scientific literacy' approach
- That considerable support and training for teachers is needed to make it work well
- That assessing IaS through written examinations is still problematic

Some issues

- Implementation
  - Getting the classroom realisation closer to our aspirations
- Assessment
  - Developing written assessment that reflects the course aims and encourages good teaching
- Dealing with the reaction to ‘scientific literacy’
  - From some sections of the media and the scientific community
  - Criticisms often based on little real knowledge of the course, or the school context

A teacher's view

"*Twenty First Century Science* is harder to teach, you need to be more creative in producing practical activities, you need more access to ICT and the coursework takes a good, strong teacher to manage well. But from the eyes of students it is a universe ahead of anything else."

(Extract, letter from Head of Science)