

THE UNIVERSITY *of York*



Twenty First Century Science

implementing a school science curriculum with choice for all

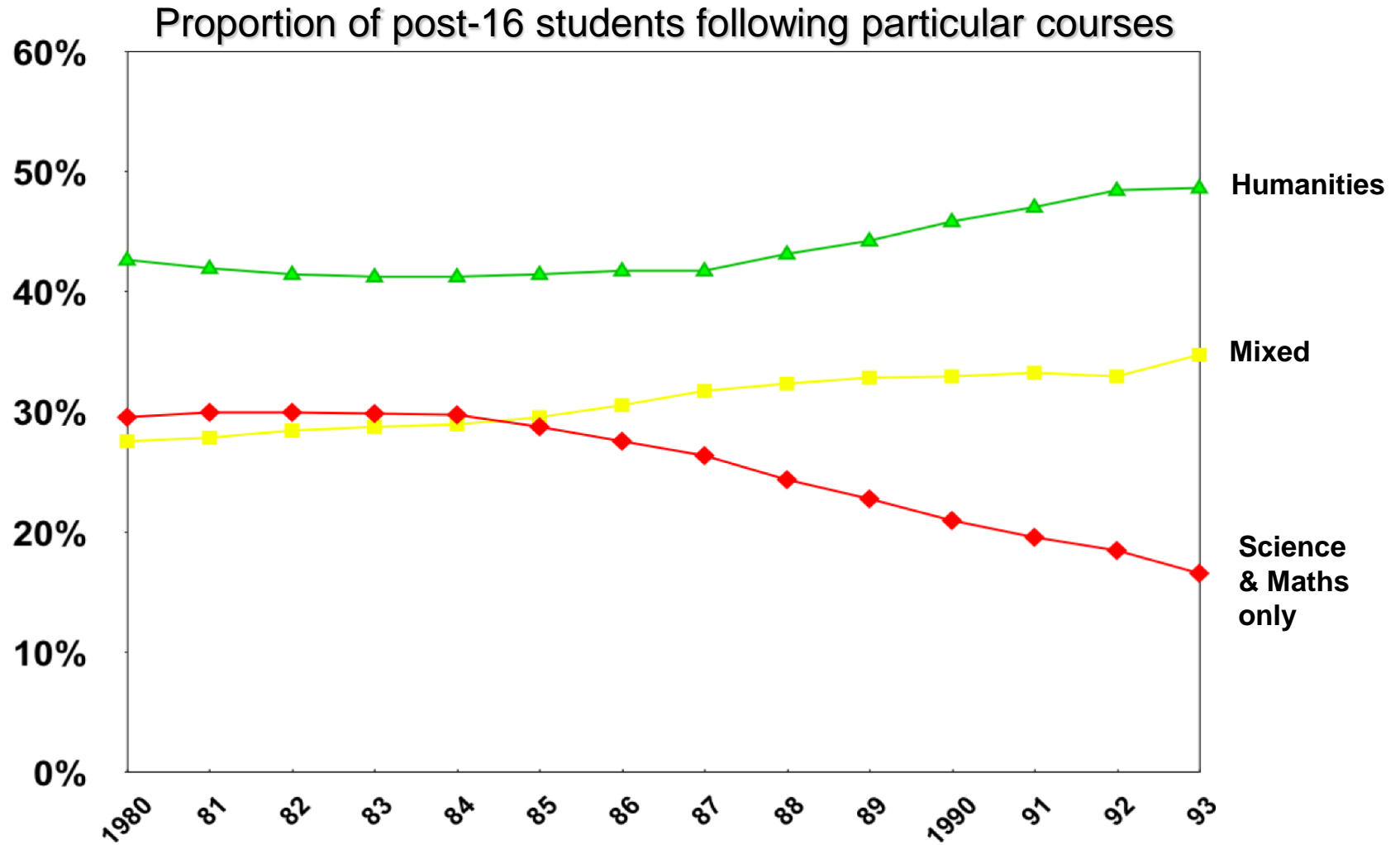




- Why change?
- Clarifying ‘scientific literacy’
- Designing *Twenty First Century Science* (C21)
- Assessing scientific literacy
- Outcomes

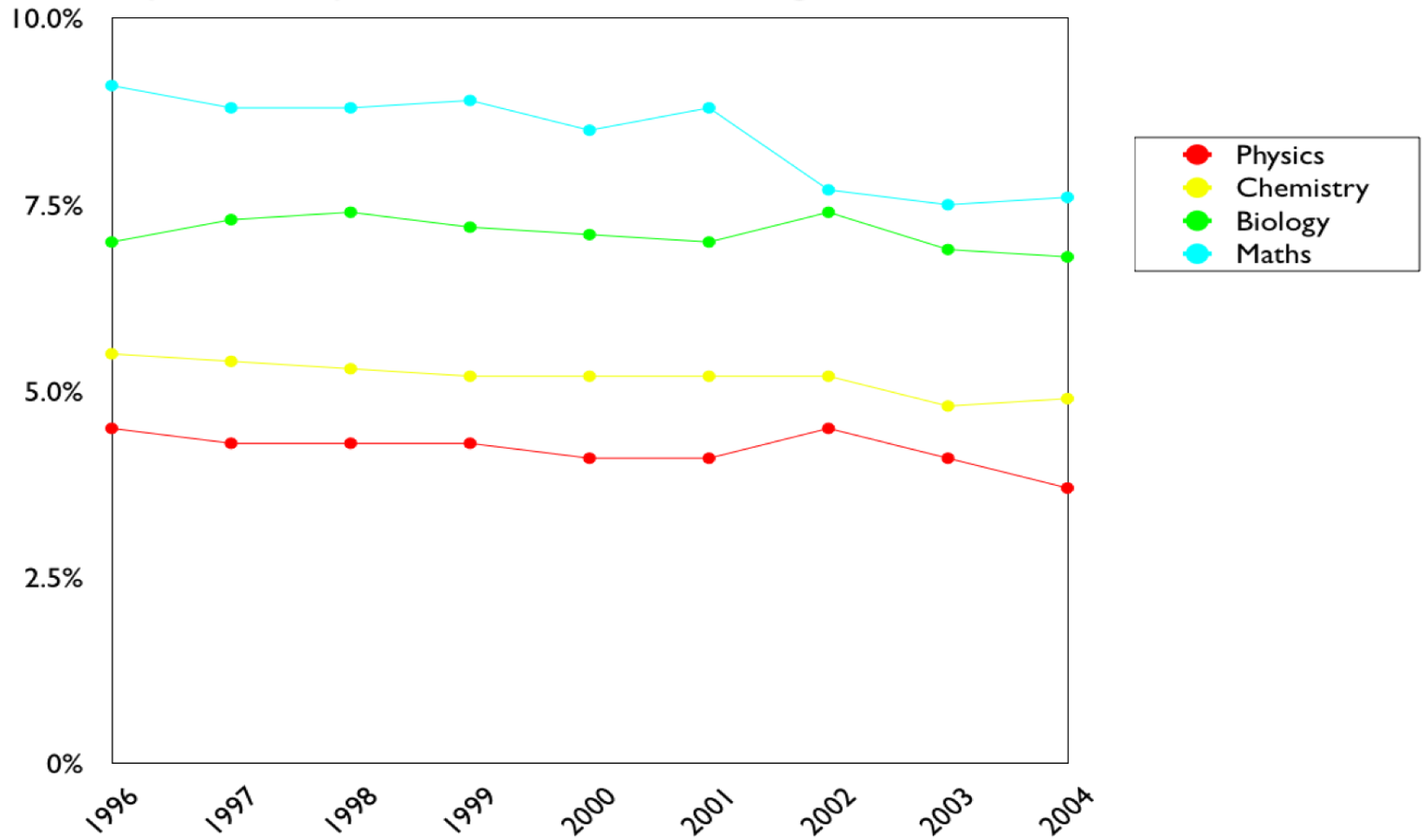


Why change?





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)



- 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)



A key distinction





Very few of us
become
producers of new
scientific
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... we all engage with
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Science education
should aim to improve
the quality of this
engagement.



- “The science curriculum from 5 to 16 should be seen primarily as a course to enhance general ‘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)



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))



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

10% curriculum time

Emphasis on
scientific literacy

(the science everyone
needs to know)

for *all* students

GCSE Additional
Science

10% curriculum time

or

GCSE Additional
Applied Science

10% curriculum time

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



- 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





What science do we meet everyday?

Exclusive Official study shows that air pollution causes the disease affecting 5m Britons

Revealed: car fumes give children asthma

BY GEOFFREY LEAN
Environment Editor

Pollution from car exhausts causes asthma, dramatic new official research shows.

A massive study, backed by the Californian and US governments, has demonstrated for the first time that ozone, the main component of smog, can cause healthy children to develop the life-threatening condition. Top British scientists believe it has provided the "smoking gun" that finally links pollution to the disease.

Inside



Leading scientist calls for petrol ban, page 3; Comment, page 22

Britain has the disease - which 18,000 new cases are diagnosed each week, and people die from it every day - which began

Professors have called for a ban on petrol cars.

Childbirth in 30s adds to breast cancer risk

BY LINDA DICKWORTH
Social Affairs Correspondent

Women who have their first child at an early age are at a higher risk of developing breast cancer, a new study has shown.

The protective effect of having several children was apparent in women who were

locks alternative power as US puts its faith in the status quo

Bush and Britain worlds apart on climate control

BY MICHAEL MCCARTHY
Environment Editor

ONE EARTH, one atmosphere: one future. But yesterday, the Governments of the United Kingdom and the United States set out two very different approaches to protecting the world from the threat to us all

proposal to be taken that way: effect of his long-awaited climate change policy.

out of at least 60 per cent in CO2, a figure readily endorsed in June 2000 by Britain's Royal Commission on Environmental Pollution in its own global warming report.

People who sleep for more than eight hours a night 'do not live as long'

BY STEVE CONNOR

PEOPLE WHO sleep for more than eight hours a night do not live as long as those who sleep for six hours, according to the biggest study yet into sleep patterns and mortality.

Scientists have no explanation for the findings and do not know if they mean people should aim for a bit less sleep.

eight hours a night is vital for health and well-being, a new study has found.

Dr Daniel Kripke, a professor of psychiatry at the University of California, San Diego, who led the study published in the *Journal of General Internal Medicine*, said: "The study found that the best survival rates were among the men and women who slept for seven hours a night. The one who slept for eight hours were 12 per cent more likely to die

ade amount of sleep. From a health standpoint, there is no reason to sleep longer," said Dr Kripke. "Additional studies are needed to determine if setting your alarm clock earlier will actually improve your health."

The scientist, who was funded by the American Cancer Society, found that the best survival rates were among the men and women who slept for seven hours a night. The one who slept for eight hours were 12 per cent more likely to die

during the six-year period of the study, when other factors such as diet and smoking were taken into account.

Even those who spent more five hours a night in bed slept longer than those who slept eight or more hours. However, an increasing death rate was found among those who slept for less than five hours.

Dr Kripke said: "Previous sleep studies have indicated that both short and long durations had higher mortality rates. However, none of those studies were large enough to distinguish the difference between seven and eight hours a night, until now."

Within the six-year period, 6.1 per cent of the women had died and 6 per cent of the men.

The causes of death were not specified.

who occasionally suffered from insomnia were not found to have any significantly increased risk of a premature death, those who regularly took sleeping pills did.

"Insomnia is common," said Dr Kripke. "Patients who occasionally suffered from insomnia were not found to have any significantly increased risk of a premature death, those who regularly took sleeping pills did."

Vitamins may hold key to birth disorder

BY SARAH WESTCOTT

SCIENTISTS ARE to investigate whether thiamine can prevent pre-eclampsia, a condition that affects 10 per cent of pregnant women and kills hundreds each year.

- 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



What do you need to deal with this?

- Some understanding of major scientific ideas and explanations
(Science 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*(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.]*



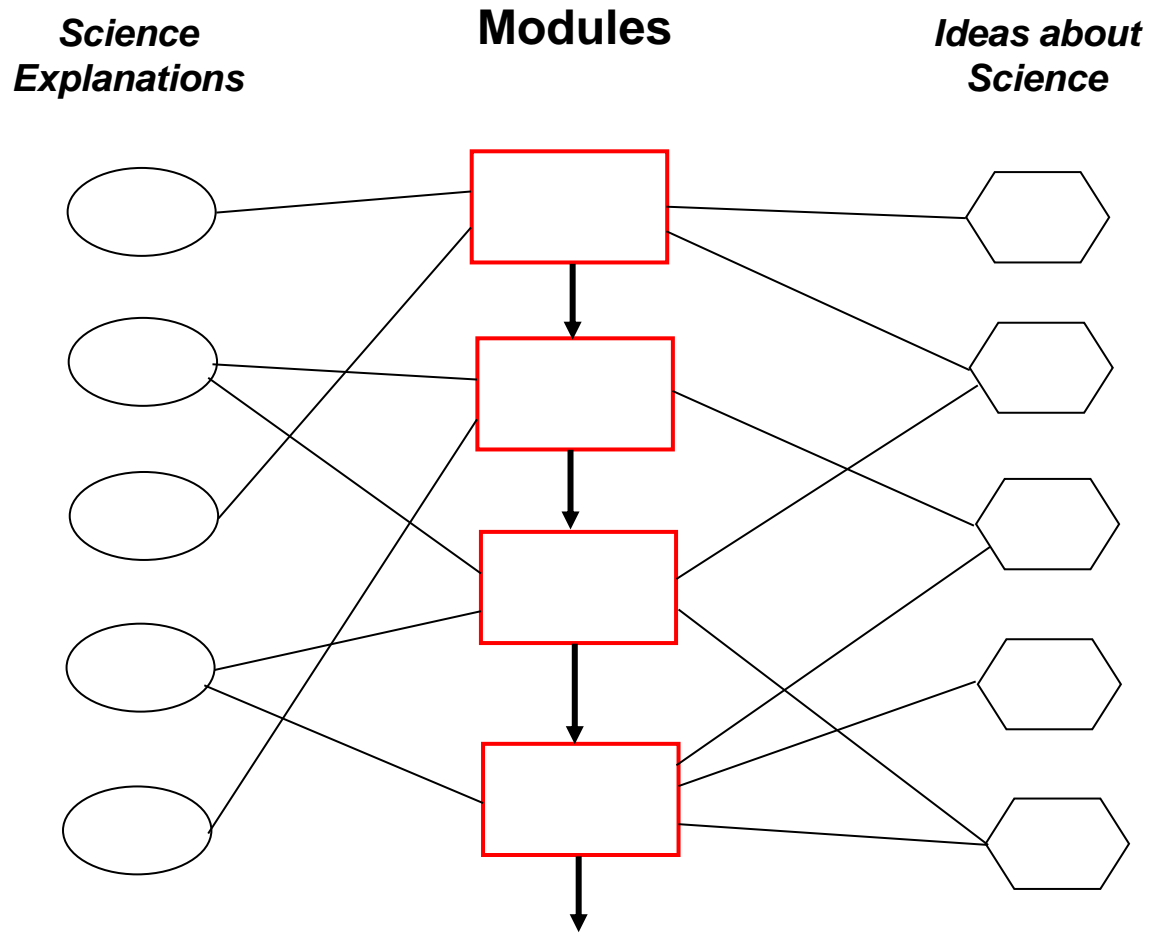
- Focus on the ‘big ideas’ of science
 - the idea of a ‘chemical reaction’ as a rearrangement of atoms; nothing created or destroyed
 - the gene theory of inheritance
 - the theory of continental drift and so on ...
- Aim for a broad, qualitative understanding
- Depth of treatment: only as much as a non-scientist requires





- 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







- 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



- 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.



<i>Coding of open responses</i>	<i>Number of teachers</i>
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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<i>Coding of open responses</i>	<i>Number of teachers</i>
Very different	20
Different	19
Not much difference	1



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:

<i>Coding of open responses</i>	<i>Number of teachers</i>
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



- 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



Three studies:

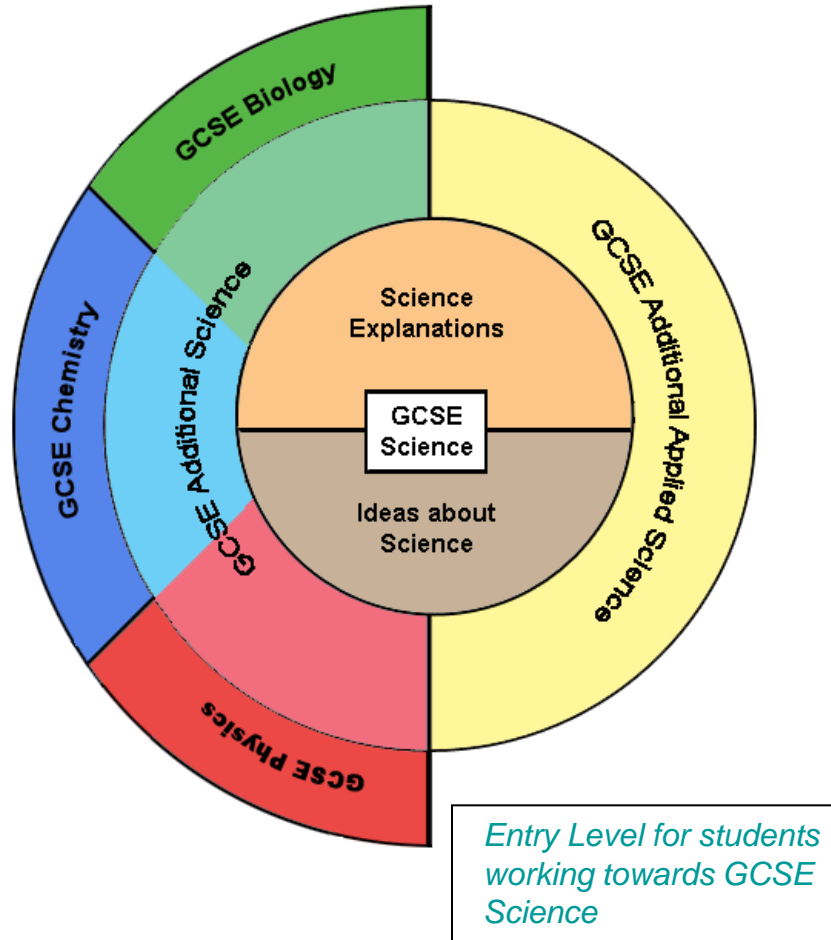
- Student learning compared with other science courses
- Students' attitudes towards science and school science
- Teachers' and students' views of the scientific literacy course, and its classroom implementation
- <http://www.21stcenturyscience.org>
(go to 'Rationale' then 'Evaluation')



- 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





- 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



- 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



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



- **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



“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)