TWENTY FIRST CENTURY
science

STEPPING STONES

Activities for teaching
Ideas about Science in GCSE Science

TWENTY FIRST CENTURY SCIENCE

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These materials were written by teachers attending *Twenty First Century Science* residential conferences during 2007. The residential conferences are arranged by the University of York Science Education Group (UYSEG) and Nuffield Curriculum Centre. To receive information regarding future conferences email uyseg-c21@york.ac.uk.

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Introduction

Twenty First Century Science is a suite of GCSE science courses incorporating specifications for:

Entry Level
GCSE Science
GCSE Additional Science
GCSE Additional Applied Science
GCSE Biology
GCSE Chemistry
GCSE Physics

The **GCSE Science** course is designed to develop the scientific literacy of all students. In order to be scientifically literate an individual needs to know some science, but they also need to know something about how this knowledge has been generated. The GCSE Science course therefore develops students understanding of particular scientific concepts (referred to as **Science Explanations**) and ideas about the nature of science (**Ideas about Science**).

The specification identifies six key Ideas about Science:

IaS1 Data and its limitations
IaS2 Correlation and cause
IaS3 Developing explanations
IaS4 The scientific community
IaS5 Risk
IaS6 Making decisions using science and technology

The materials in this booklet were produced by groups of teachers participating in a 90 minute workshop. The purpose of the workshop was to identify simple ways in which the key concepts of each IaS could be presented to students, through either non-science or science-based contexts. The activities are designed to stimulate student's thinking about particular Ideas about Science; to generate discussion about the importance of understanding Ideas about Science; to build students' confidence in their grasp of Ideas about Science, so they may apply this understanding to new areas of science as they meet them.

We would anticipate that colleagues will wish to use these activities as starting points for their own lesson ideas. New activity ideas would be very much welcomed by the *Twenty First Century Science* team. Please email your suggestions to uyseg-c21@york.ac.uk. We will update this publication periodically.

Each activity is presented as explanatory notes for teachers, which may be accompanied by student sheets if required.

IaS1 Data and its limitations

Using non-science context data to teach the key concepts of data and its limitations. When these ideas are secure students can apply them to scientific data.

Non-science data presented to students must allow for the discussion of:

- outliers
- mean
- range

Example: class attendance %

Provide pupils with names and attendance % for a class (this can be fictional data).

Pupils identify outliers, calculate range and mean, and generate a graph using Excel.

Compare class data to data for different days and/or national data (national annual absence data is available from http://www.dfes.gov.uk/schoolattendance/otherintitiatives/absence.cfm and http://www.dcsf.gov.uk/performancetables/).

Suggest reasons for differences between different data sets, e.g. particular day/date (potential to link with IaS2).

IaS2 Correlation and cause

Using a non-science context to introduce ideas of correlation and cause.

Question: What colour car are you most likely to have an accident in?

Students have three minute small group discussion and reach a consensus (maybe one or two colours).

Teacher presents data from web: http://www.bbc.co.uk/northernireland/oyb/transport_travel/car_colour.shtml suggesting there is a correlation between car colour and accident rate.
Students return to groups and suggest:
(i) a reason why this pattern exists
(ii) a counter argument to this reason
(iii) what further information they would need to feel more confident that having, for example, a silver car, *caused* you to have more accidents than other colour cars

Draw out idea of *correlation* (link between two factors) and *cause* (where there is evidence for a mechanism for how one factor could affect another).

Further information:
http://www.theaa.com/cbg/goodadvice/commongoodadvice.jsp?menu1=0&menu2=1&fileName=colour suggests there is no evidence for a correlation between car colour and accident rate.

IaS2 Correlation and cause

Using a simple non-science context to distinguish between correlation and cause.

This activity leads into a science-based context where students apply these ideas (C1 activity on MOT tests and air quality).

Teacher introduces activity with short quote:

“Newspaper article stated that an American scientist has measured the IQ and foot size of 1,000 school pupils. They found that pupils with bigger feet had higher IQs”.

Pupil small group discussion to suggest causes for this finding, followed by quick feedback to class, e.g. using snowball technique with post-its.

Teacher then provides extra information: “Researchers looked at children aged 5-16 years.” and asks pupils if they would like to modify their ideas.

Pupils quickly appreciate distinction between correlation and cause, and this key language can be introduced, e.g. there is a *correlation* between foot size and IQ, but having large feet does not *cause* high IQ, or vice versa. In a group of 5-16 year olds the older pupils will have both larger feet and generally perform better on the IQ tests.

Suggestion: Other stimulus questions could include ‘Does playing darts cause you to be overweight?’ (see www.pdpa.co.uk homepage for image)

IaS2 Correlation and cause

Using a non-science context to distinguish between correlation and cause.

This activity also provides opportunity to practice data analysis techniques (*IaS1 Data and its limitations*).

Provide football league table data for the start of a season, predictions for how particular teams will do in that season, and data from the end of the season.

Pupils look for correlations within the data:

- Do more goals scored give better position in league table?
- Do away game wins cause better positions?
- Other correlations they think may be important?

Use data for several years to determine what does effect their final position.

Take 10 years of data to plot range, mean and spot outliers

Different groups could repeat the exercise for different areas of the table, e.g. top 5, middle 5, bottom 5.

IaS2 Correlation and cause

Using a topical science-based context to distinguish between correlation and cause.

Teacher provides stimulus information on affect of ‘Sunny D’ drink on a child (http://news.bbc.co.uk/1/hi/wales/578945.stm).

Discuss claims of hyperactivity ‘caused’ by certain additives (http://www.food.gov.uk/news/newsarchive/2007/sep/foodcolours, http://lifeandhealth.guardian.co.uk/food/story/0,,2163224,00.html)

Pupils carry out a survey during lunch break to gather data about perceived effects of soft drinks.

Pupils keep a mood food diary for a week when they eat different foods (e.g. avoid sweets and soft drinks with additives).

IaS2 Correlation and cause

Using a non-science context to distinguish between correlation and cause.

In pairs students collect data for one or more of the following variables at several football clubs:

- cost of individual players (for one particular club)
- position played by a player (for one particular club)
- salary of individual players (for one particular club)
- average salary of players (for all clubs in a league)
- size of ground (for all clubs in a single league)
- league position (for all clubs in a single league)
- number of goals scored per game (for all clubs in a single league)
- cost of season ticket (for all clubs in a single league)

Pairs join together into groups of four and each group plots scatter graphs of data between two particular variables, e.g. cost of individual plavers vs salary of individual players, position in league vs size of ground.

Students identify correlations and suggest possible causes for each correlation.

Suggest a mechanism for a cause (how it happens), which could be supported by data from further investigations. Without a mechanism for how factor X causes factor Y, cannot say that this is more than a correlation.

Students may suggest refinement of variables, e.g. for some variables plotting data for strikers only gives stronger correlations, since this removes one other major variable.

IaS3 Developing explanations

Using non-scientific context to introduce ideas about the development of explanations.

Select a context dependent upon class interests, local interests, e.g. a sporting controversy headline (penalty, sending off etc).

Provide two newspaper reports with opposing views of the incident (and video evidence at the end of the activity if time permits).

Half the class read each report, without knowing that they have different articles.

Remove source articles and ask students to line up along a continuum from definitely think decision was correct at one end, to definitely think it was incorrect at the other end.

Pair students together (each student having read opposite article from their pair).

Give two to three minutes for a short discussion about what they think happened during the incident.

Ask students to line up again, then raise their hands if they have changed their position in the line.

Students are likely to have worked out that they had different articles. Ask them what might happen if you provided several more articles (e.g. more of them may change their position on the line).

Draw out idea that they re-evaluated their decision in light of new evidence. Illustrate process of developing scientific explanations by describing a scientific context where ideas have changed with new evidence.

IaS3 Developing explanations

Using non-scientific contexts to introduce idea that the same data may be interpreted in different ways.

Set the scene – a young man is running away from an old lady lying on the floor, clearly very distressed. A second man in jeans and a hoody top is rummaging through her bag.

Ask students: What conclusions can you draw from this data? What caused this set of events?

Answers usually include robbery, mugging etc.

Then offer an alternative interpretation: The old lady is having an angina attack and has asked one of the men to look in her bag for her medication. The other man is running for help.

IaS3 Developing explanations

Using non-scientific contexts to introduce idea that new evidence may result in modification of existing explanations.

Use a Cluedo style PowerPoint with images from a crime scene.

Ask for an explanation of the available data – what happened at this scene?

Provide more data (more views from the crime scene).

Do students want to modify their explanation?

As more data is provided, explanations may, or may not , be modified. However at each introduction of new data current explanation is always revisited, to check whether this data supports it or not.

IaS3 Developing explanations

Using a non-science context to introduce ideas about developing explanations.

Jumping to conclusions or developing explanations?

Ask students to suggest an explanation for a particular situation, e.g.:

- A student arrives late to lesson smelling strongly of smoke.
- In the yard, you see lots of students running towards a large group of students all shouting.
- Why don't Australians fall off the Earth?
- Did man really go to the moon?

Provide structure for students as appropriate, e.g. what questions might you want answered to help you develop your explanation? e.g.:

- What is the data?
- Are there other possible explanations as well as mine?

Quickly note down students' explanations on the board.

Introduce further data for, e.g.:

- Student has a note from their parent.
- Music can be heard coming from the large group of students.

Ask students if they wish to revise their explanation.

Further questions:

- What is the role of imagination for each explanation?
- Which explanation is the best? Why?

IaS3 Developing explanations

Using a science context to introduce ideas about developing explanations.

Fact: dinosaurs became extinct at the end of the cretaceous period.

Question: Why?

Clues ….

Iridium is a rare element but is found in meteorites.	There is a layer of iridium rich rock all around the world formed at the same time.	Sea levels were very high during the late Cretaceous period.
Towards the end of the Cretaceous period there were huge volcanic eruptions in India.	There is a buried crater in Mexico formed at the same time.	Nearly all life became extinct 250 million years ago. No crater has been found at this age.
Flowering plants had evolved towards the end of the Cretaceous period.	Many species of dinosaur had already become extinct before the end of the Cretaceous period.	There are other large craters around the world which do not seem to have caused mass-extinction. ?250 million years ago there were massive volcanic eruptions.

IaS3 Developing explanations & IaS4 Scientific community

Using non-science context to introduce ideas about IaS3 & IaS4.

Spot the ball!

Difficulty of prediction (IaS3.2, 3.3, 3.4, 3.5)

Scientific community (IaS4.1, 4.3, 4.4)

3.2 Imagination – develop explanation
3.3 Make prediction based upon new data
3.4 Comparing predictions based upon data from observations
3.5 More data needed – no answer yet
4.1 Share findings – initial predictions
4.2 Collaboration to share data and help provide explanation
4.4 Do not abandon ideas – need more evidence?

IaS4 Scientific community

Non-scientific context: Big Brother

Reasons that cause general public to vote for contestants:

- gender
- family member
- what part of country they are from
- race
- what has happened to them in the week

Real World Hook: Global warming causes/factors

- sponsorship of research
- scientific bias

IaS5 Risk

Using non-science context to introduce key concepts of risk.

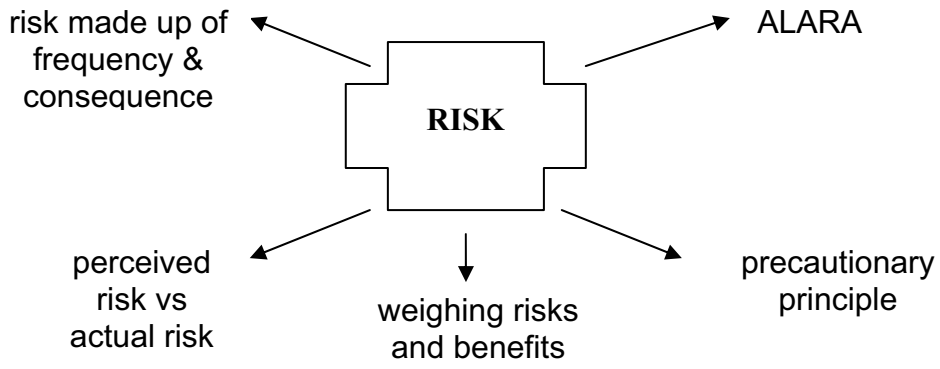
Suggestion: Explain how to make a decision involving risk

Teacher provides students with lots of 'Would you …?' statements, for example:

- cross the road on a red man?
- swim in the sea straight after lunch?
- jump off a wall?
- truant a science lesson?
- miss a homework deadline?
- eat a yoghurt that is past its sell by date?
- share a can of drink with a friend?

Students feedback their decisions with reasons, and teacher draws out concepts of risk, building up overview diagram (see below).

Students add example of each key concept to their notes.



IaS5 Risk

Using a science-based context to introduce concepts of risk.

Starter: Ask the question ‘Would you dive into a pool not knowing how deep the water is?’

Ask students to suggest similar types of questions from their own experiences (e.g. would you cross the road at a bend where you could not see oncoming traffic?).

Main: Teacher introduces the science around WiFi technology, and some of the arguments for and against.

Students brainstorm how each group feels using jigsaw approach.

Teachers

Students

Governors

Expert scientists

Parents

Head Teacher

WiFi production company

Move into discussion groups with one of each ‘expert’.

Discuss “Do we put WiFi technology into our school classrooms?”.

Plenary: Take feedback from the class, covering views of groups that agreed and disagreed. Use student feedback from groups that said ‘no’ to introduce concept of the precautionary principle.

IaS5 Risk

Using a non-scientific context to introduce IaS5.3.

Give students a bank of statements, e.g. risk of getting caught 'bunking', smoking, not doing homework.

Ask students to put these statements in order of risk.

Get students to give the 'chance' a quantitative value (1 to 10).

Ask students to discuss the consequence of each statement and then quantify this (1 to 10).

From this they can then calculate their perceived risk by multiplying the two values together.

Rank the statements a second time, based on the calculated perceived risk. How does this compare with their initial ranking?

IaS5 Risk & IaS6 Making decisions about science and technology

Using a science-based context to introduce concepts of risk and decision making.

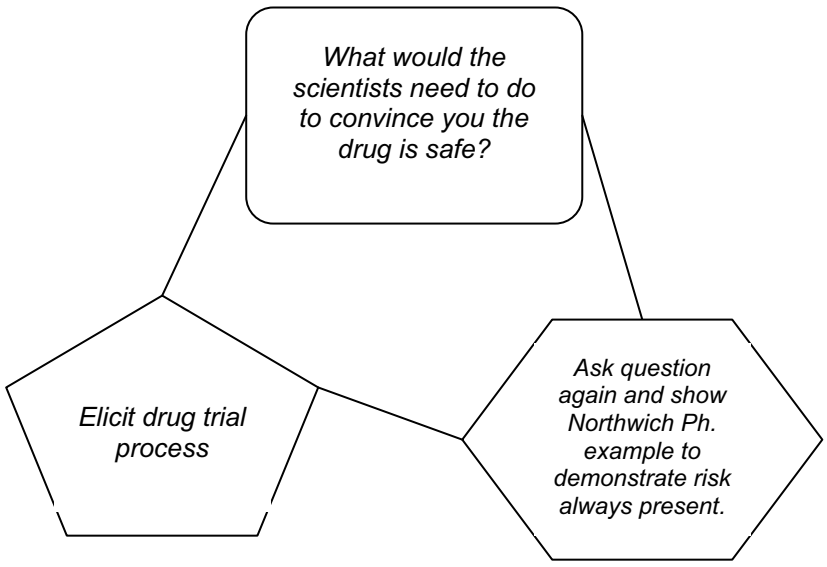
Teacher describes Edward Jenner's early experiments to test a smallpox vaccine on a small boy. Ask pupils if they would volunteer for such experiments?

Group activity 'mock' blind drug trial.

Coloured cards with 'drug' or 'placebo' and different set with numbers 1, 5 or 10.

Outcome – serious harmful effects result from the cards combination 'drug' and '10'.

Ask pupils if they would you take part in a drug trial for £5,000?



IaS5 Risk & IaS6 Making decisions about science and technology

Using a non-science context to introduce ideas of risk, which are then applied to a scientific context (in module B2).

A: In pairs discuss what the term ***risk*** means and write down a definition.

Provide students with a list of sporting activities, e.g. grandma walking up road, skiing, football, bobsleigh, bowls. Ask students to rank this list of activities, then justify the criteria they used to make their decision (and thus what they understand by risk).

As a whole class consider the question 'Does risk mean harm?'.

B: Starter: Provide information (e.g. laminated newspaper articles or printed web pages) which discuss the advantages and disadvantages of using the MMR vaccine.

Main: In small groups students discuss: 'Is there a risk?'.
Collect very brief feedback from groups.
Using their textbook as an additional source groups discuss: 'Is any risk from the MMR vaccine an acceptable one?'

Plenary: In small groups students list examples of acceptable/unacceptable risk from everyday life.

Get feedback from groups, discussing the reasons they consider a particular risk acceptable/unacceptable (the risk itself, i.e. likelihood & consequence, and for risks they feel are unacceptable also the perceived payoff from the activity).

Homework: AB2.10 Vaccine scares.

IaS5 Risk

Using non-science context to make concept of risk explicit.

Provide laminated A4 grid, ten laminated cards (five events and five frequency cards), OHT pens and calculators.

Consequence	Frequency (likelihood)	Perceived Risk		Rank
10			=	
20			=	
30			=	
40			=	
50				

Students place event cards on what they think is correct relative level of consequence (10, 20, 30 etc).

Students decide which frequency card to assign to each event card.

Students multiply number under event card with number on frequency card to calculate perceived risk, and then write in ranking of each event (from one to five) for relative perceived risk.

IaS5 Risk

Using non-science context for students to calculate likelihood of a particular risk, and recognise other factors that affect risk.

This activity could be used as a quick starter or extended as appropriate.

Ask students to briefly describe premise of the “Deal or No Deal” TV programme.

In small groups students calculate likelihood of picking £250,000 and 1p.

Ask what is the role of the dealer – how does he affect likelihood of contestant winning £250,000?

Compare likelihood of a contestant winning £250,000 with likelihood of a contestant winning Big Brother.

Only twelve contestants for Big Brother, so does this mean each contestant has a 1/12 chance of winning?

IaS5 Risk

Using non-science context to introduce ideas about risk.

Write a paragraph describing a very risky day or walk to school.

For example: My day on a tropical beach
"I swam through shark infested waters … relieved to survive I sat beneath coconut tree and lit up a cigarette. Found I'd lost my suntan lotion, but could not be bothered to cover up."

Students highlight risks in their paragraph and then rank them, explaining the reasons for their ranking.

Small group discussion - how are you going to improve your chance of living longer?

IaS5 Risk

Using non-science context to introduce ideas about risk.

Pictures:

Activity:
Would you play (runaround!)
Would you still play
etc ….

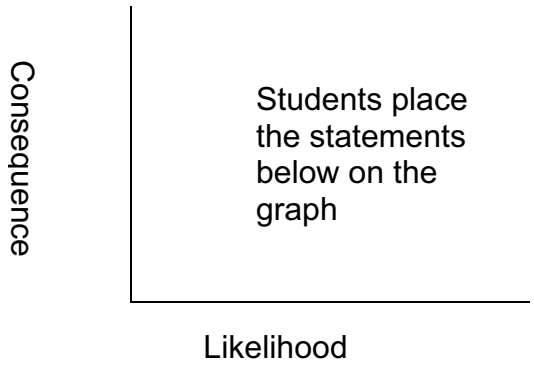
Questions:
What is the risk?
Why make your choice?

Key Ideas:
To make a decision about a particular risk we need to take account of both the **chances** of it happening **and** the **consequences** if it did.

IaS5 Risk

Using a non-science context to introduce ideas about risk.

RISK = likelihood (of happening) and consequence (if it did)



- being in a plane crash
- missing a day of school because you are ill
- cutting yourself shaving
- losing mobile phone
- returning home after curfew *
- failing your GCSE's*
- winning the lottery
- dying of heart attack/stroke
- getting bitten by a shark
- "Town Name" underwater due to global warming

*variable consequences so discuss with your group/partner

Extension questions: Suggest ways of reducing the likelihood of the risk. Is your judgement of the size of the risk actual or perceived? Can you do anything about the consequences?

IaS5 Risk

Using a non-science context to introduce ideas about risk (IaS5.3, 5.4).

Describe the game Russian roulette.

The game is being played using a gun with two barrels, one with a bullet, the second chamber empty.

Consequence is high, likelihood is high.
Most people choose not to take the risk.

Offer people £100

Do students think more people would take the risk?

Offer people one million pounds.

Would more people take the risk?

A new gun is developed for the game. It has 1000 barrels, still only one chamber with a bullet.

Offer people £1. Most people choose not to take the risk.

Offer £10,000.

Do students think more people would take the risk?

If so, why?

IaS5 Risk

Using non-science context to introduce ideas about risk (IaS5.3, 5.4).

Starter: Would you play ….

Students given a series of questions and must justify why they would/wouldn't play cricket without any protective kit:

- at all
- if playing with a soft ball
- as an outfield player (with hard ball)
- as a bowler
- as a batsman
- as a batsman against a less-skilled player
- as a batsman against 1st XI player
- as a batsman against county player
- as a batsman against Flintoff?

Make active by using Leitart Scale for students to show where they stand (from definitely yes to definitely no).

(Alternative scenario – would you play as a hockey goalie without kit?)

IaS6 Making decisions about science and technology

Using a science-based context to introduce concepts of sustainable development.

Growing fruits & vegetables in polytunnels, having them available all year at Tesco.

Brainstorm students' favourite fruits and vegetables. Select some of these and ask when they are available.

Draw out ideas of seasonal foods, growth of certain fruits and vegetables being grown in polytunnels and/or flown from other parts of the world to the UK to give year-round availability.

Discuss impact on the environment, people in immediate community and other communities.

IaS6 Making decisions about science and technology (focus on 6.5 and 6.6)

Using a non-science context to develop students' understanding of ethical frameworks.

Teacher poses question to students: 'Should you shop someone you have seen shoplifting?'

Give students series of steps to follow:

Identify people involved and how each group is affected

Split the class into four groups. Each group has one of the ethical frameworks given in IaS6.6 as a basis for discussion of the pros and cons of this question. Each group produces a grid to record their discussion.

Re-sort the class so one from each group from (2) are together to discuss their individual ideas.

Come up with a decision and then discuss as a whole class.

….. *relate frameworks to making "right and wrong decisions" in science*

[Note: 'Simpletons' activity from Upd8 is a useful resource for this approach (http://www.upd8.org.uk/activity/201/Simpletons-an-ethics-tool.html).]

IaS 6 Making decisions about science and technology (focus on 6.7, technical feasibility)

Using science-context to explore ideas about technical feasibility (B2 *Keeping healthy*, lesson 5 vaccine policy).

Starter: Video IB2.5 Smallpox and discussion (10-15 mins)

Main: Stimulus material of newspaper article or news clip about the incidence/death rate/effects on population of a particular disease in a developing country, e.g. polio.

In pairs students consider: “Why, when vaccinations have been available for so long, for so many diseases, is it not possible for the above country to eradicate this disease?”

Use snowball technique to arrive at class consensus.

Plenary: Students write short summary paragraph explaining IaS6.7 using the context they have discussed.

IaS 6 Making decisions about science and technology

Using non-science context to introduce ideas about decision making.

Introduce context: buying a dress

6.1 Cost/benefit
What is it for?
How much do you want to spend?
How many times will you wear it?
Who do you want to impress?

6.2 Sustainable?
Keep for a long time?
Buy second hand?

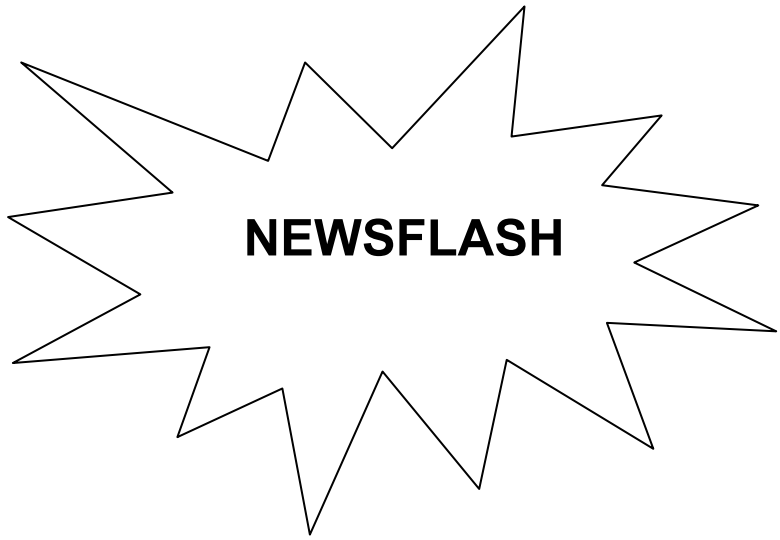
6.3 Regulations
Is it decent?

6.4 Ethical
Would you buy a fur-trimmed garment?

6.7 Feasible
Can you get into it?

IaS6 Making decisions about science and technology

Using a science-based context to introduce ideas about decision making.



Vaccination preventing cervical cancer to be available for girls at around 14 years old.

Ethical questions:
Should there be herd immunity?
Costs of programme?
Costs to society (boys, age, unprotected sex)?
How?

IaS6 Making decision using science and technology

Using a non-science context to introduce ideas about decision making

‘Touching the void’ scenario – a cliff hanger.

Question: Would you cut the rope - survive fall factors affect self – now and future.

IaS 6 Making decisions about science and technology

Using non-science context to introduce ideas about decision making.

This activity uses the context of technology in sport. It could be used to discuss several IaS:
IaS1 Limitations of the data
IaS3 Confidence in explanation/confidence in technology
IaS4 Different viewpoints, e,g, linesman, umpire, crowd, TV pundits, hawkeye

Show a short video clip of a sporting event, e.g. penalty in football.

Students given 2 cards (red/yellow or penalty/not penalty etc) and ask to make a decision.

Show a series of short clips from Wimbledon (either historical – present clips or lots of clips of the same match). Include a clip where 'Hawkeye' is used to make the decision.

Classroom discussion: Should we use technology, e.g. 'Hawkeye', in football?

Go back to original football issue – show it from a different angle. Do they still agree with their original decision?

[N.B. Video footage of the disallowed England try in the 2007 Rugby World Cup final from different angles would be a very good example.]

IaS 6 Making decisions about science and technology

A non-science context to introduce discussion of controversial ethical decisions (IaS6.5).

Set the scene: “With five minutes to go in a school football match, a team mate dives and wins a penalty. Your team goes on to win the game.”

Questions for small group discussion:

What’s the controversial question in this situation?

Ethics is about what is right or wrong behaviour. Is this an ethical question?

What are the views of:

(a) yourself (a team mate)?
(b) your P.E. teacher?
(c) a player from the opposing team?

People may justify their ethical decisions with different reasons. Which person is using these justifications:

(i) Some things are wrong whatever the reason.
(ii) Sometimes a behaviour is ok if it’s for the good of the group, even if some people are hurt a bit by it.
(iii) Something is wrong if many people are hurt by the behaviour.

IaS 6 Making decisions about science and technology

A non-science context to introduce discussion of controversial ethical decisions (IaS6.5).

There is a 20-a-day smoker in your family, who has two small children.

What is the ethical issue?

What are the views of:
(a) the smoker
(b) the children
(c) a health professional
(d) yourself?