# How teachers assess

# Develop and teach a course

- Teachers develop and teach a course using the General Objectives and the required subject matter in the syllabus
- The General Objectives are essentially what students should be able to do

# Choosing the assessments

- Teachers then select the assessments they will use
- Syllabus includes the assessment requirements
- E.g. Mathematics C syllabus requires 5 pieces of assessment, including 2 assignments

# Writing the assessments

- Teachers develop tests and assignments to assess what they have taught

# Setting a Test

- An example – Mathematics C

# Setting a Test

- What content am I testing?
- What objectives am I testing?
- Are students given an opportunity to reach all standards?
- Where is this information?

The syllabus.

# Syllabus Content

## *Matrices and applications* (notional time 30 hours)

***Focus***

Students are encouraged to develop an understanding of the algebraic structure of matrices including situations where they form groups. Students should apply matrices in a variety of situations and use technology to facilitate the solution of problems involving matrices.

***Subject matter***

- definition of a matrix as data storage and as a mathematical tool (SLEs 1–7)
- dimension of a matrix
- relationship between matrices and vectors (SLEs 1, 6, 7, 12)
- matrix operations
  - addition and subtraction
  - transpose
  - multiplication by a scalar
  - multiplication by a matrix (SLEs 1–7, 13, 14, 15)
- inverse of a matrix
- solution of simple matrix equations
- definition and properties of the identity matrix (SLEs 1, 3, 15)

# Objectives

### *Knowledge and procedures*

The objectives of this category involve recalling and using results and procedures across the range of subject matter in this syllabus.

By the end of the course students should be able to:

- recall, access, select and apply mathematical definitions, rules and procedures
- demonstrate number and spatial sense
- demonstrate algebraic facility
- select and use mathematical technology
- demonstrate knowledge and use of the nature of mathematical proof.

### *Modelling and problem solving*

The objectives of this category involve the uses of mathematics in which the students will model mathematical situations and constructs, solve problems and investigate situations mathematically across the range of subject matter in this syllabus.

By the end of the course students should be able to:

- apply problem-solving strategies and procedures to identify problems to be solved and interpret, clarify and analyse problems
- identify assumptions (and associated effects), parameters and/or variables during problem solving
- represent situations by using data to synthesise mathematical models and generate data from mathematical models
- analyse and interpret results in the context of problems to investigate the validity (including strengths and limitations) of mathematical arguments and models
- modify mathematical models as appropriate.

### *Communication and justification*

The objectives of this category involve presentation, communication (mathematical and everyday language), logical arguments, interpretation and justification of mathematics across the range of subject matter in this syllabus.

By the end of the course students should be able to:

- interpret and use appropriate mathematical terminology, symbols and conventions
- organise and present information for different purposes and audiences, in a variety of representations (such as written, symbolic, pictorial and graphical)
- analyse information displayed in a variety of representations (such as written, symbolic, pictorial and graphical) and translate information from one representation to another
- develop coherent, concise and logical sequences within a response expressed in everyday language, mathematical language or a combination of both, as required, to justify conclusions, solutions or propositions
- develop and use coherent, concise and logical supporting arguments, expressed in everyday language, mathematical language or a combination of both, when appropriate, to justify procedures, decisions and results
- justify the reasonableness of results obtained through technology or other means using everyday language, mathematical language or a combination of both
- provide supporting arguments in the form of a proof and recognise that a proof may require more than a verification of a number of instances.

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# How do I grade a test?

Which standard does the student’s response match [A, B, C, D, E]?

How have the student’s responses matched the standards in the 3 objectives?

Where do I find this information?

The Syllabus.

# Using the standards

- Teachers use standards to make judgments about **each** piece of student work
- The standards identify how well students demonstrate the objectives in the syllabus
- The five standards in each general objective are the common reference point for all schools. They ensure that judgments are consistent across the state

# The Standards

## 6.9 Standards associated with exit criteria

| Criterion | Standard A | Standard B | Standard C | Standard D |
| --- | --- | --- | --- | --- |
| *Knowledge and procedures* | The student work has the following characteristics:<br>• recall, access, selection of mathematical definitions, rules and procedures in routine and non-routine simple tasks through to routine complex tasks, in life-related and abstract situations | The student work has the following characteristics:<br>• recall, access, selection of mathematical definitions, rules and procedures in routine and non-routine simple tasks through to routine complex tasks in life-related and abstract situations | The student work has the following characteristics:<br>• recall, access, selection of mathematical definitions, rules and procedures in routine, simple life-related or abstract situations | The student work has the following characteristics:<br>• use of stated rules and procedures in simple situations |
| | • application of mathematical definitions, rules and procedures in routine and non-routine simple tasks through to routine complex tasks, in life-related and abstract situations | • application of mathematical definitions, rules and procedures in routine or non-routine simple tasks, through to routine complex tasks, in either life-related or abstract situations | • application of mathematical definitions, rules and procedures in routine, simple life-related or abstract situations | |
| | • numerical calculations, spatial sense and algebraic facility in routine and non-routine simple tasks through to routine complex tasks, in life-related and abstract situations | • numerical calculations, spatial sense and algebraic facility in routine or non-routine simple tasks, through to routine complex tasks, in either life-related or abstract situations | • numerical sense, spatial sense and algebraic facility in routine, simple life-related or abstract situations | • numerical sense, spatial sense and/or algebraic facility in routine or simple tasks |
| | • appropriate selection and accurate use of technology | • appropriate selection and accurate use of technology | • selection and use of technology | • use of technology |
| | • knowledge of the nature of and use of mathematical proof | | | |

# The objectives example

Question 1. Knowledge and procedures

C/B Standard:

- Recall, access and select mathematical definitions, rules and procedures in a routine, simple abstract situation

# The objectives example

- Question One (KP) [C B Standard- recall, access, selection of mathematical definitions, rules and procedures in a routine, simple abstract situation]
-
- Part I- Use the method for approximating small changes in the value of a function to find a value for $\sqrt{82}$ to 4 decimal places.
-
- Solution
-
- Let $f(x) = \sqrt{x} \Rightarrow f'(x) = \frac{1}{2\sqrt{x}}$
- Let $x_0 = 81$ *and let* $\Delta x = 1 \Rightarrow f(81) = 9$ *and* $f'(81) = \frac{1}{18}$
- Hence $f(82) = f(81+1) \approx f(81) + \Delta x . f'(81)$
- $= 9 + \frac{1}{18}$
- $\frac{163}{18} \approx 9.0556$

# The Criteria Sheet

| KP | Standard specifics | Standard | Student response |
|---|---|---|---|
| Q1 | • Recall, access and select mathematical definitions, rules and procedures in a routine, simple abstract situation | C | ✓ |
| Q2 | • Appropriate selection and accurate use of technology<br>• Recall, access and select mathematical definitions, rules and procedures in a routine abstract situation | B/C<br>B/A | ✓ |
| Q3 | • Recall, access and select mathematical definitions, rules and procedures in a routine life related situation<br>• Application of mathematical definitions, rules and procedures in a routine complex task in a life related situation<br>• Application of mathematical definitions, rules and procedures in a non-routine task in a life related situation | B/C<br>B/A<br>B/A | ✓<br>✓<br>✓ |
| Q4 | • Numerical calculations, spatial sense and algebraic facility in a routine life related situation | B/C | ✓ |
| Q5 | • Application of mathematical definitions, rules and procedures in a routine complex task in an abstract situation<br>• Application of mathematical definitions, rules and procedures in a routine complex task in an abstract situation | A/B/C<br>A/B/C | |
| Q6 | **• Recall, access and select mathematical definitions, rules and procedures in a routine complex abstract situation.**<br>**• Recall, access and select mathematical definitions, rules and procedures in a routine complex abstract situation** | **A/B/C**<br>**A/B/C** | |

# Feedback

- The syllabus standards help teachers to provide useful feedback because their judgments are based on the evidence that matches the standards
- Students learn what they are doing well and where they can improve
- Parents have a clear idea on what the possible problem areas are and how to improve

# Deciding level of achievement

- At the end of a course, teachers award a final grade for a student – an “exit level of achievement”
- They use the collection of student work (called a folio) to determine an overall standard for each of the three objectives

# Example of Student Profile

## A Queensland School

Student: A Student

### Mathematics C

Years: 2011 - 2012

### Student profile

Teacher: A

*Teacher*

| Semester | Assessment instrument | Knowledge and Procedures | Modelling and Problem Solving | Communication and Justification | Comments, if applicable |
|---|---|---|---|---|---|
| 3 Summative | Test | A | A | A | |
| | EMPS | B | A | A | |
| | Test | A | B | A | |
| 4 Summative | EMPS | A | C | B | |
| | Test | A | A | A | |
| **Summaries** | | **KP** | **MPS** | **CJ** | **LoA** |
| | **Verification** | A | B | A | VHA |
| | **Exit** | A | B | A | VHA |

# Awarding exit levels of achievement

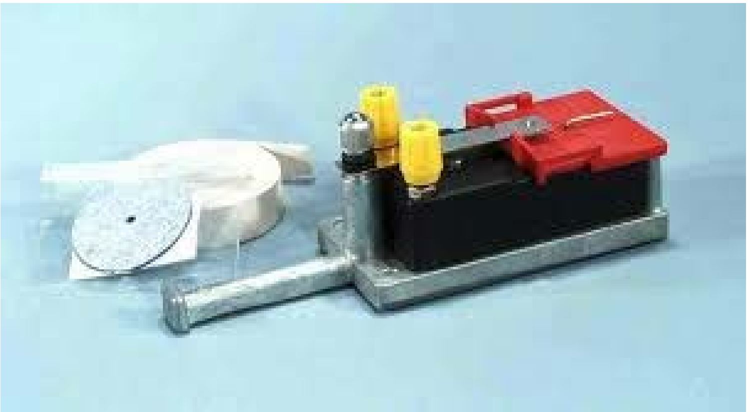
| | |
|---|---|
| VHA | Standard *A* in any two criteria and no less than a *B* in the remaining criterion |
| HA | Standard *B* in any two criteria and no less than a *C* in the remaining criterion |
| SA | Standard *C* in any two criteria, one of which must be the *Knowledge and procedures* criterion, and no less than a *D* in the remaining criterion |
| LA | At least Standard *D* in any two criteria, one of which must be the *Knowledge and procedures* criterion |
| VLA | Standard E in the three criteria |

# Extended Experimental Investigations

Why and how?

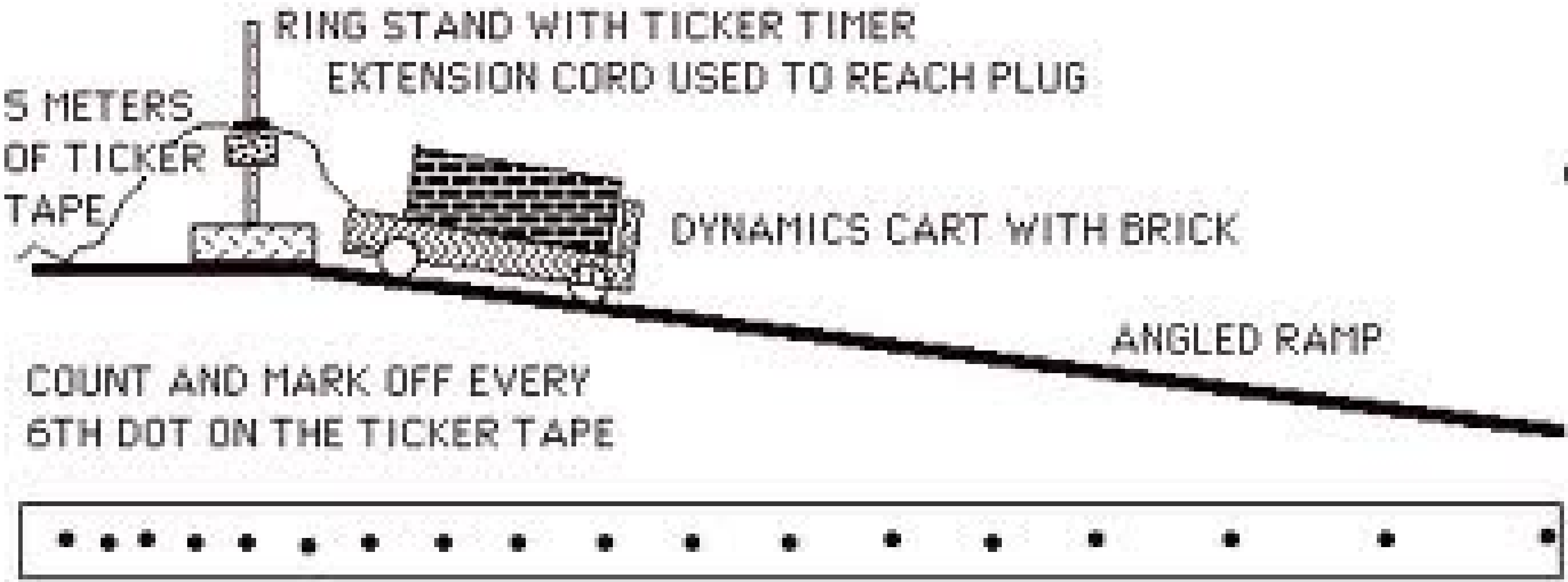
# Science education has changed

- Traditional science course
  - Content focussed
  - "Recipe" pracs used to demonstrate content



- Rationale
  - Scientists needed to know content
  - Pracs were limited by equipment available

# The inclined plane experiment



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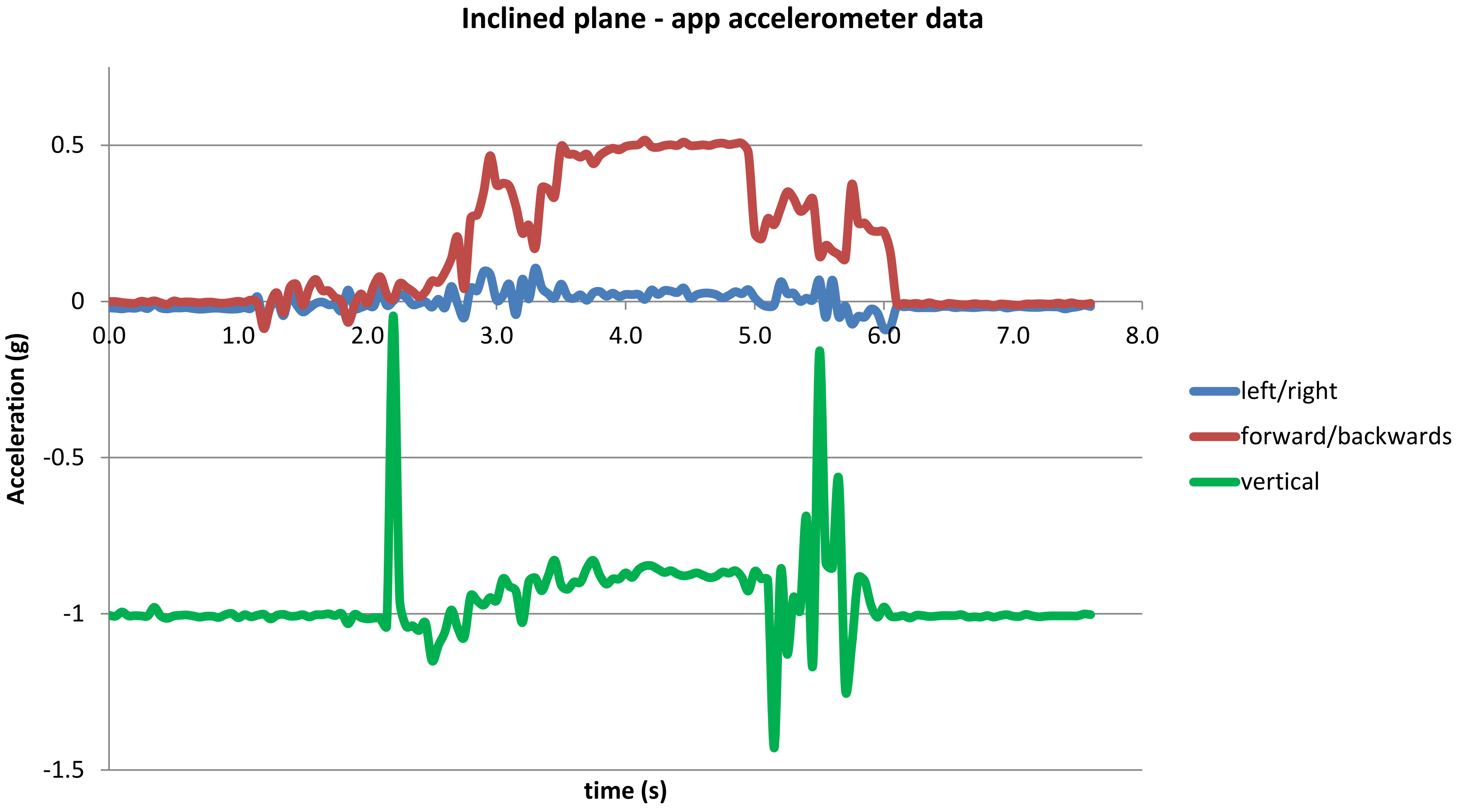

# Science education has changed

- Modern science
  - Process focussed
  - Focus on fundamental concepts
  - Experiments imitate the work of real scientists

- Rationale
  - Technology changes
    - what we need to remember
    - what we can do

# Designing an EEI

- What do we want students to show they can do?
  - Learn some new Science
  - Design and perform an experiment
  - Critically analyse their results
  - Communicate what they have learnt

# Designing an EEI

**Extended Experimental Investigation**

**Term 4**

**SET:** 8 October **DUE:** 9 November

TASK: Investigate how the Laws of Physics apply to a particular toy, game or sport.

OR

Investigate the optics relevant to the construction of a telescope.

The investigation will consist of:

- a review of relevant scientific literature (if necessary)
- a simple experiment that explores a physical concept linked to a game or sport
- further experimentation that more closely models an application of physics concepts. (This may be a development of the simple experiment or an entirely new experiment.)

SUGGESTIONS:

Students could investigate the physical principles governing one of the following:

- Playground equipment (eg. swings, see-saws)
- Billiards
- Design of sporting equipment:
  - Shoes
  - Racquets
  - Balls
- Projectile motion of balls
- Construction of a simple telescope
- Chromatic aberration
- Refractive index of different materials

Other relevant investigations may be pursued subject to discussion with the teacher.

TIMELINE

| | |
|---|---|
| Week 1: | Risk assessment/First phase of experimentation |
| Week 2: | Second phase of experimentation |
| Week 3: | Submit draft |
| Week 4: | Conferencing |
| Monday 5 November: | Submit Introduction/Analysis to TurnItIn |
| Thursday 8 November: | Submit final edition |

# Designing an EEI

- Key features
  - Context and choice
    - Engages students’ interest
  - Authentic inquiry
    - Students (and teachers) finding out something they didn’t know
  - Restricted scope
    - Time limit
    - Word limit
    - Group work

# Designing an EEI

- Key features
  - Guidance
    - Start with a familiar experiment
    - Timeline
    - Draft

# Managing an EEI

- Strategies
  - Time in class
  - Log books
  - Conferencing and feedback
  - Draw on prior experience
  - Constant reference back to the standards

# Marking ‘prac work’

- Using marks
  - Create a model solution
  - Compare to model solution and assign marks
  - Add up marks and compare to total available
- Works well for recipe ‘pracs’
- Does not work well for an open-ended EEI

# Grading an EEI

## The influence of temperature on bouncing balls

### Introduction:

When a ball is bounced, a number of energy conversions occur. Initially, the ball has gravitational potential energy which is the energy of any object that is held above ground level and is determined by its height and mass (ScienceThinking, 2011). It can be described by the equation:

$$E_{gp} = mgh$$

As the ball falls, this gravitational potential energy is converted to kinetic energy, the energy of motion, which is described by the equation:

$$E_k = \frac{1}{2}mv^2$$

(University of Virginia, 2011).

In order to calculate the velocity with which the ball collides with the ground, it is assumed that at this point all the gravitational potential energy has been converted to kinetic energy. In the case of a ball dropped from a low height, this assumption is quite accurate. However, when talking about greater heights, the possibility of terminal velocity comes into play and this assumption becomes less accurate. Terminal velocity is occurs when the downward thrust is equal to the wind resistance. However, this is unlikely within the scope of this experiment. With this assumption, the equation of kinetic energy can be used to find the velocity. Once the ball hits the ground, it deforms and the kinetic energy is converted to elastic potential energy (Madden, 2011). However, as no ball is perfectly elastic, this conversion is not perfectly efficient and so some energy is lost to heat and sound. Eventually, the restorative force restores the ball to its previous shape and in doing so converts the elastic potential energy back to kinetic energy, which in turn is converted to gravitational potential energy as the ball rises (University of Virginia, 2011). However, the ball will not return to its original height, due to the energy lost to heat and sound. The difference between original and final height be analysed using the coefficient of restitution.

The coefficient of restitution is a measure of the change in velocity in a collision, and in the case of a bouncing ball it represents the ratio of the final velocity over the initial velocity:

$$e = \frac{v_f}{v_i}$$

It can also be calculated using:

$$e = \sqrt{\frac{h_f}{h_i}} \qquad \text{(Madden, 2011)}$$

The coefficient of restitution can thus be used to compare how well different balls bounce. One factor that can influence the bounce of a ball is the temperature of the ball. A warmer ball will bounce higher than a cold one. The reason for this is twofold. In a hollow ball, the change in temperature causes a change in air pressure within the ball. In an enclosed situation, air pressure is directly proportional to temperature (Cook, 2011). Lowering the air pressure by lowering the temperature has an effect similar to deflating the ball. Increasing the temperature, and thus air pressure, has the effect of over-inflating (Boetz, 2011). The other way in which temperature influences the height a ball bounces is by impacting its elasticity. Elasticity is a measure of how well the ball's kinetic energy is converted to elastic potential energy; the less energy lost to heat and sound, the more elastic the substance (Madden, 2011). The balls used in this experiment, squash balls, are made of rubber which is made from long polymer chains. These polymers are tangled and stretch upon impact. However, they will only stretch for a short time before their atomic interactions pull them back into their original shape, and thus transfer that elastic potential energy back to kinetic energy (University of Virginia, 2011). When the ball is heated, it becomes more elastic, as the bonds are able to move more freely and thus are able to stretch more than those in a cooler ball, and thus less energy is lost (Boetz, 2011). This then means that the ball bounces higher. Under cold conditions the material can become so rigid that it becomes an "energy sink" which absorbs energy rather than transferring it (Boetz, 2011).

**Aim:** To investigate the influence of temperature on the coefficient of restitution of squash balls.

# Grading an EEI

- Standards approach
  - Read the task
  - Read and understand the standards
  - Read the work
  - Annotate the work and criteria sheet to identify evidence
  - Make a judgement

# Grading an EEI

- Is it subjective?
  - All marking requires judgement
  - Grades can be defended by with evidence
  - Examples
    - Complexity
    - Systematic data analysis
    - Select ideas with discrimination

# Grading an EEI

- Does it take longer?
  - Not in my experience
  - Reasons it can seem slower
    - Students writing over the word limit
    - Providing feedback
    - No zeroes
  - Not more marking than other faculties

# Grading an EEI

- Do you end up with the same result?
  - For some students, yes
  - For some students, no
    - Very high achieving students
    - Students with language difficulties
    - Students who have specific weaknesses (e.g. maths)

# Some comments from personal experience