AQA
Realising potential

GCSE science: Virtual communities

Autumn 2021

Welcome

Today's agenda

- Supporting students in their application of practical skills in unfamiliar contexts.
- Updates and notices from the Relationship Manager.
- Materials you should have access to:
  - slides and *Resources* booklet
  - facilitation pack (this will be available after the session).

Reports from 2018, 2019 and the limited 2020 exam series showed that students often struggle with questions addressing practical investigations – especially when the context of the investigation is unfamiliar.

Exam paper format and make up is not changing for 2021 or 2022 (further than that we can't say), so the requirement for at least 15% of marks for practical (most of which in unfamiliar contexts) could be even more of an issue for students taking exams next year (and possibly 2023 and 2024).

What can we do, with the limitations there have been and still are on opportunities for learning from varied practical work, to help students progress to confidence in dealing with such questions, and gain/regain/hone these skills?

Focus of today's meeting

- What we mean by progressing from 'hands-on' to 'minds-on' using the Working scientifically criteria.
- Helping widen student experience with the limited time you have:
  - experimental methods from GCSE exam papers
  - developing a framework to help students interrogate unfamiliar methods and investigations in exam questions to progress to 'minds-on'.

We'll be looking at ideas you may have heard about if you attended this autumn's CPD on student progression: hands-on and minds-on. It's one of the approaches in Project Calibrate, which I'll introduce later in the meeting.

We'll look at key aspects of the Working scientifically criteria that AQA assess in the practical-based exam questions. Only part of these criteria cover the physical aspects of carrying out practical work.

Although students are back in school there still may not be time to do as much practical work as you would like.

This meeting focuses on the variety of experimental methods and scenarios in the GCSE exam papers, which you could use to develop a develop a framework of generic questions to help students progress from 'hands-on' to 'minds-on' and give them confidence in tackling the unfamiliar practical situations presented to them in exams.

What do we mean by ‘hands-on’ and ‘minds-on’?

- What do you understand by the phrases ‘hands-on’ and ‘minds-on’ as aspects of practical investigations?
- Use the Working scientifically criteria to help (*Resources* booklet pages 4–5).

First as a group, discuss what the phrases ‘hands-on’ and ‘minds-on’ mean to you.

Looking at the Working scientifically 2 and 3 criteria from pages 4-5 in the Resources booklet, discuss with colleagues which aspects of the criteria could be ‘hands-on’ and which ‘minds-on’

Differences between ‘hands-on’ and ‘minds-on’

- A student who has had the opportunity for ‘hands-on’ can:
  - follow a method correctly
  - manipulate apparatus correctly and safely
  - make and record observations and results
  - present data in an appropriate format.
- A student who has had the opportunity for ‘minds-on’ can **also**:
  - understand the reasons for using a particular method
  - understand what variables need to be manipulated, if any
  - understand why variables are being (or not being) manipulated
  - understand about sampling
  - understand about sources of error and how to minimise them
  - use their understanding to choose appropriate methods for different situations.
- That is, they can think like a scientist as well as carry out procedures.

Students who have had the opportunity to experience ‘hands-on’ will be able to carry out the physical aspects of investigations such as those listed here.

But there are many other aspects of scientific investigations that this approach doesn’t necessarily cover. These are the ‘minds-on’ aspects, some of which are listed on the slide.

These are the ‘soft’ practical skills if you like. Developing them means students will be more able to apply any knowledge they have gained from one context to another.

Looking at the split-up Working scientifically criteria (pages 7-8 of the Resources booklet) can you see how the two aspects work together to give a student a deeper understanding of what scientific investigation involves?

Advantages of using a ‘minds-on’ approach

- Develops the ability to apply practical skills to different situations.
- Students understand more about the principles behind the investigation, rather than simply memorising a recipe, so:
  - are more able to cope with the unfamiliar situations in practical-based exam questions
  - develop transferrable skills for later study/work.
- Embeds these principles in student thinking so they are more confident:
  - independently working at A-level to achieve CPAC criteria
  - doing independent practical research when progressing to higher education.
- Encourages a more open approach to practical investigation.
- Makes practical work more interesting/engaging/applicable.

In exam papers most of the practical-based questions are set in a context students are unlikely to have come across, so being able to apply what they have learned in one context to a different context is really important in terms of how well they do.

It means that they can look behind the unfamiliar context to the science underneath and use their understanding of that science to answer the questions. And this skill of looking below the surface can be transferred to further study and in world of work.

At A-level independent thinking and understanding of why students are doing what they are doing is part of the CPAC criteria for the practical endorsement as well as the exam questions.

And building these skills will give students a head start when they start independent study at university.

Using questions to aid progression to ‘minds-on’

- Our GCSE exam questions cover some aspects of these ‘soft’ practical skills, but not all of them in any one paper. Therefore, the use of whole exam questions is limited in this context.
- Take any method and use targeted questions to explore the science beneath the method.
  - Use a framework of generic questions to draw from for any method
  - Questions can be adapted for specific methods or to change the demand
  - You could include tables of results for further analysis.
- Start with a familiar context (eg a RPA) then progress to unfamiliar ones to give students confidence in tackling unfamiliar contexts.

How can we help students achieve this confidence without doing many different variants on practicals?

The exam questions have to assess many aspects of a student’s knowledge and understanding and only parts of any one question are going to cover ‘minds-on’. So, using whole exam questions is going to have limited use if you’re looking to really embed minds-on thinking.

Exam papers do all contain questions based on familiar and unfamiliar contexts for investigations. You could use source materials (eg the method/experimental set up) as the basis for class- or homework to help enhance student understanding: first in a familiar context, then in the much less familiar context.

As a science department you could build a bank or framework of generic questions that you can use to explore different aspects of the WS criteria and give students the skills to look deeper into the practical. You could even build sub-sets of types of questions addressing different levels of demand.

The usefulness of such a bank is that your whole science department could use it for all three sciences, reinforcing the thinking across the cohort.

You could use the same example several times, posing different questions from the bank to explore and develop confidence in different aspects, as short exercises or homework.

Activity 1: Using familiar contexts

- Look at Example 1 on page 9 of the *Resources* booklet. This is a Required practical and students should be familiar with the set-up.
- What questions could you ask students about this method to progress their minds-on thinking?

By starting with questions based on familiar investigations students can build their confidence before going on to tackle investigations in unfamiliar contexts, which often throw them in exams.

What we want to do here is think of ways we could get students to interrogate the method to really enhance their understanding of the minds-on aspects, so that if they come across a different set up or slightly different investigation they can relate what they have learned to that situation.

Example 1 (page 9 of the Resources booklet) is a method from the 2019 Biology 1F question 9. It should be familiar to students, as it directly relates to Biology RPA 6 (Investigate the effect of light intensity on the rate of photosynthesis using an aquatic organism such as pondweed).

As a group think about what sort of questions you might build into the bank around this example.

Types of questions

- There is a range of categories of questioning a method, in which you will have a bank of specific questions you could use for any example.

- These categories could include:
  - developing or testing hypotheses
  - variables
  - sampling/controls
  - making predictions
  - types of measurements
  - errors
  - evaluating the method.

Within each of these categories there are many different questions you could ask to draw out different aspects of the method and enhance understanding. So you are starting to build up a bank of generic questions – at the moment not in any particular order, and not aimed at any particular level of demand.

These could be used for both familiar and unfamiliar methods.

If an investigation in an unfamiliar context is presented to them many students panic, become unable to relate it to any of their knowledge and either answer wrongly or miss out the question completely.

AQA are required to base a proportion of the practical exam questions on unfamiliar contexts so for a student to achieve their potential it's important for this not to happen.

So you need to include questions within the bank that will help students look behind the unfamiliarity and understand that they do know or can work out the answers by applying their knowledge.

Activity 2: Using unfamiliar contexts

- Look at examples 2, 3 and 4 on pages 10–12 of the *Resources* booklet.
- Each one is unlikely to be a method or investigation your students have had direct experience of.
- For each one consider:
  - the Required practical to which it relates
  - how confident you think your students would be in answering questions about this investigation
  - what experience a student would need to be able to deal with questions relating to this example.
- What extra questions might you add to your framework to help students with unfamiliar contexts?

Examples 2, 3 and 4 are each based on a Required practical, but the methods described are unlikely to be ones your students have followed – so are going to be unfamiliar.

As a group, consider each example:

- Can you recognise the Required practical to which it relates?
- Would your students be able to answer questions about this investigation, or would the context throw them?
- What further practical experience might they need to tackle variations on required practicals?

What extra questions would you add to your bank that would help students see beyond the unfamiliar context?

Further questions for unfamiliar contexts

Questions you might want to add could include:

- the area of subject content it covers
- whether students can see that it's a variant on a required practical
- how it's different from the practical they've done
- what clues they can see in the wording of the investigation to what knowledge they need to apply.

For unfamiliar contexts you need students to be able to use the information given to relate it to the subject content they have studied or a practical they have done.

Once they do that they gain the confidence to start looking behind the unfamiliarity and understand that they do know or can work out the answers by applying their knowledge.

There is an example framework of questions you might want to start with on page 13 of the Resources booklet.

Introducing Project Calibrate

- Joint project between Oxford University and AQA, funded by the Wellcome Trust, Gatsby Foundation and the Royal Society.
- Aims of the project:
  - to broaden the scope of practical science at Key Stage 4
  - to give students a better understanding of the wide variety of methods scientists use while conducting investigations.
- Approach:
  - 'hands-on' and 'minds-on' practical science
  - challenges the simplistic, step-by-step process of 'the scientific method' as hypothesis testing through experiments
  - uses a tool called Brandon's Matrix to give an account of diversity in scientific methods.
- Free teaching and CPD resources for teachers on different approaches to practical work, including sample summative assessments.

On screen: Project Calibrate

This project presents information and ideas for you to go further into the hands-on/minds-on approach to practical work.

The approach taken develops the 'hands-on'/'minds-on' approach we've been looking at today.

The underlying framework of practical science the project uses is called **Brandon's Matrix**.

A fairly typical depiction in school of how science is done involves the so-called 'scientific method'. According to this model, scientists begin with a question they want to answer. They then design an experiment and, by carefully tracing independent and dependent variables, they produce findings that help them answer the question.

The project challenges this traditional linear model: scientists engage in a wide array of methods, some of which include hypothesis testing and some other approaches including those where there is no manipulation of variables.

The project has developed a range of free teaching and CPD resources which you may like to take a look at.

What is Brandon's Matrix?

	Changing variables	Not changing variables
Testing a hypothesis	**Manipulative hypothesis testing** Testing a hypothesis by changing independent and dependent variables. **Example:** Testing the hypothesis that foods high in carbohydrates increase blood sugar levels by measuring blood sugar levels (dependent variable) with different types of food (independent variable).	**Non-manipulative hypothesis testing** Testing a hypothesis via a situation that can't be manipulated. **Example:** Testing the hypothesis that green ink is a mixture of yellow and blue inks by observing the pattern of inks produced in a chromatogram of a sample of green ink
Making measurements and observations	**Manipulative description or parameter measurement** Investigation to measure the effects of changing conditions or variables on outcome(s). **Example:** Observing the effect of different concentrations of sugar solution on the mass of potato by measuring the change in mass of pieces of potato of the same size left in different concentrations of solution for the same amount of time	**Non-manipulative description or parameter measurement** Explaining, observing, classifying, categorising, tracking, measuring. **Example:** Observing what happens to a ray of sunlight when it passes through a glass prism.

Based on information from Project Calibrate

Tool used by Project Calibrate

Challenges the traditional linear model of the scientific method in the science curriculum.

It is a simplified 2 × 2 matrix based on two questions:

1. Are we testing a hypothesis or are we making observations and measuring parameters?
2. Are we changing variables or not?

Illustrates that not all experiments rely on hypothesis testing and that not all descriptive work is non-manipulative.

This is an explanation of the four quadrants – with an example of each type of practical investigation that could be done at GCSE. For more information on the matrix and how you could use it in your teaching and learning go to the project page.

Project Calibrate: Key findings

Key findings

- The resources helped students understand scientific methods better
- Students indicated that the Project Calibrate approach helped them understand scientific methods better
- Most pupils associated the resources with practical science
- Teachers found the summative assessments useful and indicated that they would use them.

These are the key findings from the project.

Project Calibrate

Quotations from participants:

- ‘I liked the questions because they helped me really think about the experiments I have done previously.’ – Science student
- “Before I watched the videos I thought all scientific investigations require a hypothesis of some sort, which these videos disproved in an easy to understand way. Thank you for opening my eyes.” – Science student

Project Calibrate. (2020). Key Research Findings. University of Oxford.

- ‘I think it is a really good way of organising the practicals that we already have in our curriculum. It makes it really, really clear to see what we clearly do assess and what we focus on a lot. And where our areas of weakness are […] I thought it was a really good model and quite easy to understand.’ – Science teacher

Project Calibrate website

These are some words from participants in the project – both teachers and students.

Any questions?

- This is your chance to ask any questions you have.

Notices and updates for 2022

- Sources of practical questions:
  - Exampro
  - Old specification ISAs
  - Practical handbooks
- Focus on success packs
- Teaching guide: exploring common misunderstandings
- Summer 2022
  - GCSEs and A-levels
  - Practical work (GCSE and A-level) and A-level endorsement: Vocational, Technical and other qualifications; contingency plans

Get in touch

Our friendly team will be happy to support you between 8am and 5pm, Monday to Friday.

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Thank you