Teaching Resource :

Top tips for your investigations

3. FAIR TESTS & CONTROL EXPERIMENTS

Guidance for Teachers...

"Fair Test & Control Experiments" is one of **four interactive resources** designed to explain some of the simple strategies employed by real scientists whilst investigating. They represent good scientific habits which primary school children are able to learn. Exploring these will enhance critical thinking skills and give a major boost to your ESB Science Blast Investigations. Each resource can be used independently of each other. It's important to select the ones that are likely to be relevant to an investigation that you have in mind, and ideally they would be introduced to your class at an early part of the planning process.

Each resource consists of two parts:

1. **An animated video** that explains through example. Each video contains points where it should be paused to allow for class discussion and problem solving.
2. **A small group discussion exercise**. Learning is reinforced by challenging students to apply the new strategies in different contexts. Descriptions and questions are summarized on our ready to print discussion cards.

The thinking behind these strategies.

Scientist often go to great lengths to ensure that their experiments and activities produce robust and reliable evidence to support (or to discredit) explanations of how the world works. Ideally, their evidence is then offered up to be fully scrutinized by the wider scientific community by publishing the details of their results. Other scientists then take the opportunity to either repeat or find additional evidence to support (or discredit) their conclusions. It all takes time but these are the important 'hoops' that every scientific discovery has to jump through before it can be placed on the podium of "scientific fact": a position that, once earned, should be subject to ongoing scrutiny, forever! These are the ideals that science aspires to and is the basis for regarding it as a special and highly reliable way of understanding the world around us.

Primary school scientific investigations are not only exciting and stimulating learning experiences but can also sow the seeds of developing real scientific know-how. This resource is aimed at illuminating and supporting your teaching about "**fair tests**" and the use of "**control experiments**": two of the key strategies employed in the pursuit of reliable evidence.

It's important to appreciate that not every scientific investigation can make use of these approaches. It all depends on the question you are asking and the methods you develop for answering it. "**Fair tests**" may be particularly useful in investigations that are looking to **compare** things and that need you to conduct **multiple tests and experiments**. For example: "Which is the best washing liquid for removing stains in clothes?" OR "Does your height influence how fast you can run?". In these investigations you could be repeatedly testing different liquids and measuring the running abilities of people of difference heights to compare them. The key question to ask the children is "what needs to be kept the same in each of the tests you do?" or "Which **variables** need to be kept the same for each test?". The washing liquid investigation is illustrated in detail in the animation video and gives a clear example of how and why a fair test is constructed.

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Guidance for Teachers cont...

The thinking behind these strategies (cont)...

Adding a "**control experiment**" can sometimes be an **extension of a fair test** (as in the first case in the video) and they can also be used in their own right to **add greater insight when forming scientific explanations** of what is observed. For example, when testing the effectiveness of new medications, the data scientists collect is usually much stronger if they have also used a placebo or "control experiment", (medicine free doses) in a select portion of their tests. You can almost think of a control experiment as a blank or anchor experiment that everything else can be compared to. Medicine trials may seem a bit removed from classroom science but there are plenty of opportunities for children to learn about and use control experiments when investigating at this level. They may seem a slightly strange thing to do but the benefits are really clear when you try to draw together all your evidence and make conclusions at towards the end of an investigation.

Once children grasp these fundamental ideas then they will be better able to decide if their own investigations will benefit from using one or both of these strategies. These strategies should only be used if there is a clear and obvious reason to do so. Hopefully these ideas will stimulate a lot of discussion. Some children may point out that it's not fair to give someone a blank medication and raise some interesting ethical questions. These are real things that scientists have to grapple with when they design their experiments.

Using the Animated Video:

The video is designed to explain the two strategies in an engaging way, using obvious examples.

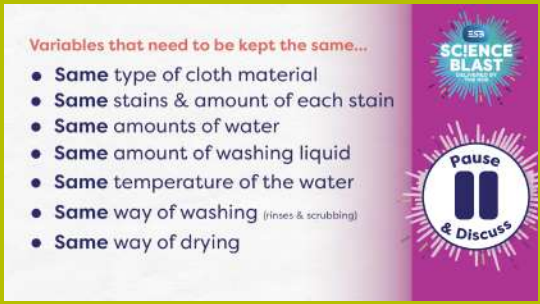
There **are four pause points** for you to open up discussion and challenge students to come up with their own solutions before the video explains further.

It is important to emphasise that the aim is to engage students and encourage critical thinking. It is not important that they only come up with the "correct" solution. They may actually come up with some other strategies that could also help in this particular situation. Encourage that kind of thinking.

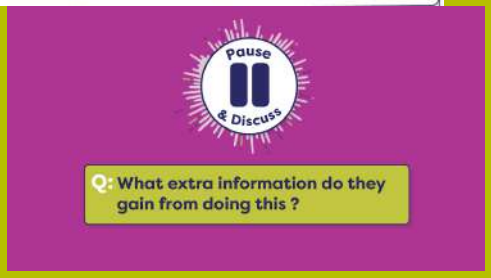
The washing liquid experiment provides a clear and transparent example of how a fair test should be constucted.
Thinking through these issues at the planning stage will greatly enhance the quality of any investigation.

The video introduces the word "variable".
Any aspect of a system that could vary is a 'variable'.
In carrying out a 'fair test' the overall aim is to create an experiment where **only one variable changes** between each of the tests. All other variables should be kept the same (if practical). At the first pause point encourage your class to try and identify the variables that should be kept the same (in advance of showing them the list of suggestions).

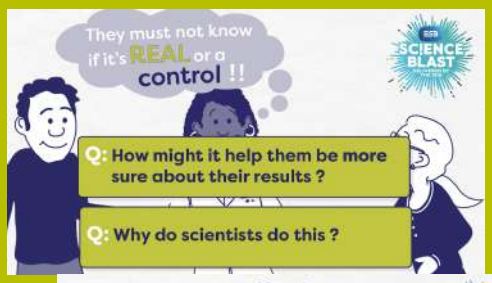
Guidance for Teachers cont...



Compare your class suggestions to our list.
This list is not exhaustive. Your class may make other sensible suggestions. It is important to emphasise that you have to **be practical and reasonable**. Scientists can never control all variables perfectly but it something they try to work towards where possible.



The video gives a clear example of what a control experiment would look like.
Some children might think that it's silly to do a washing test without any washing liquid and this is worth discussing. The whole point of going to all this trouble with fair tests and control experiments is to satisfy the question that comes at the end of an investigation; "How can I be sure of my results?" The control test provides a reference point for the whole experiment. If it turned out that in the control test the stains were removed quite effectively then that would signficantly effect how you would frame your conclusion. Scientists like to cover all these bases in their experiment designs so their conclusions are more robust...they should assume as little as possible, even if it makes them look silly!



Ethical issue may come up.
In discussing how scientists get better quality information by handing out control tablets some children may raise the issue of whether this is fair. Scientists doing these kind of trials will have explained this to the volunteers at the start and they would have volunteered knowing that they may **not** receive the medicine. In many trials the scientist themselves do not even know who gets the real medicine and who gets the placebo, until the end. This is called a "double blind" trial. From a scientific point of view this kind of trial gives the best information but they are not always possible because ethical issues trump the need to do this (eg. for cancer treatments). Many of the best Covid-19 vaccine trials were double blind trials. In those cases the scientists were able to take blood samples, ask people to report on any side effects they experienced and watch for infections. It was extremely helpful to have a sample of people who did not receive the real vaccine (but didn't know for sure) to compare everything with.

Fair tests and Control Experiments are not always relevant.
The phrase 'fair test' has become a bit of a buzz word of school science education and it can sometimes be mistaken that every science investigation has to be "fair test". This is not the case. The strategies described by our other animated resources may be more useful to the investigation you have in mind.

Guidance for Teachers cont...

Using the Learning Reinforcement Cards:

This resource comes with **3 printable cards** to choose from. Each card describes a senario that invites students to relate the ideas described in the animation video to new contexts. Ideally your class would be divided into small groups and they could discuss each scenario and the questions the card asks. If time allows their conclusions could be reported as part of a whole class discussion. Again the emphasis is on engagement. There are no definitive answers. Each card is broadly aiming for the following response....

Fair Tests & Control Experiments 1:
This example provides a simple context for the creation of a **fair test**. You would expect students to identify that it is most important to have the **same amount** (or mass) of ice cream and the **same room conditions** (air temp) as for each measurement taken . All sorts of variables could be considered (like the brand of the ice cream, or the time it's left out of the freezer before starting) but what is important is that they discuss the practicalities and the priorities of what will achieve the best result. No experiment is perfect and in any investigation you will need to weigh up what it **ideal**, and what is **achievable**. There is no need for a control experiment in this context.

Fair Tests & Control Experiments 2:
This investigation is a great one to try with older primary school children. The best results come from those who incorporate a parachute (as big as possible) with a loosely scrunched (and hence impact absorbing) cradle to hold the raw egg as it falls gently to the ground. Students should be able to identify that each group will be using the **same equipment** and have the **same time** to complete the challenge make this a fair test between competing designs. The **control experiment** that the teacher is alluding to is that she drops a raw egg (without any supports) out of the window. As well as adding dramatic effect it provides a reference when comparing the performance of all the other designs.

Fair Tests & Control Experiments 3:
This example is more nuanced and will provide a greater challenge to students. Creating perfect '**fair test**' conditions will be impossible as there are so many variables that would need to be looked at. Most volunteers would not be able to conform to this. The most sensible suggestions about how to make this test **fairer** could include.

1. Everyone is given samples of **the same brand** of coffee.
2. To ask volunteers to pick nights where their patterns of behaviour are quite similar. So maybe to avoid weekends and **use unremarkable "week nights"** instead. If they have had an usually stressful day then that would not be a good night to consider for the test either.
3. It is probably more important that people stick to going to **bed at their 'normal' time** rather than everyone going to bed at the same time. Going to bed later or earlier than normal could have an additional effect on their ability to go to sleep.

Hopefully this will stimulate **a lot of discussion** and that is a healthy part of designing a scientific investigation. There are a number of options of how you could build in a **control experiment** using the decaffeinated coffee.

Option 1: They could be open and upfront about the use of decaffeinated coffee, asking all people to complete an additional three test nights. On those nights they would drink a sample of the decaff version and report on the effects.

Option 2: They could not tell anyone about the possible use of the decaff version and continue with the original plan. When they hand out the 'coffee samples' to be used, half of them are decaff and half are caffeinated. They gather peoples reports and look carefully at the results for the decaff group. If some of them say that this coffee interfered with their sleep pattern then you can either conclude that the placebo effect is at work OR that maybe some **other ingredient** in coffee may be responsible for making it hard to go to sleep.

An investigation could of course combine both of these approaches and include more volunteers. If option 2 is preferred then your class would need to discuss if it was ok not to fully disclose information about what they were drinking, and if it was safe to do so in this context. Scientists should consider the ethics of the experiments they perform. Option 2 is likely to give greater insight and could produce more reliable data.