Planning and Setting Up a Scientific Investigation

As students begin to get started on their investigations, it's worth recapping some of the principles of scientific method with them to ensure their research is meeting the criteria on which they will be judged.

Students will have a greater chance of success if their research method takes into account:

- **Use of a hypothesis**
  Students should demonstrate a clear understanding of a hypothesis and provide one for their investigation. Hypotheses should be brief statements predicting expected outcomes and should be backed up by reasoning.
- **Use of a control or control group**
  Students should be encouraged to set up an experimental method that allows for a control or control group to be used. Judges will be directed to look for use of a control; therefore students should make this obvious in written and visual displays. Many students do not naturally think of including a control group or if they do, may not link it to the variable being tested. Teachers should help students create experiments that use valid controls.
- **Replication of treatments**
  Within any experiment, students should be encouraged to set up multiples of any treatment. At this level, use of three replicates should be seen as a minimum. Replication also applies within each treatment; for instance, encourage the use of amounts appropriate to the experiment (eg. using 20, 50 or 100 seeds per treatment instead of 2 or 3).
  Encouraging replication also provides useful discussion with students regarding why this is preferable; discussions about error, precision and accuracy, 'rogue' results, effect of outliers/extreme results, etc.
- **Repetition of experiments**
  With the amount of time provided before reports are due, most students will be able to complete more than one cycle of experiments. Judges will be instructed to look for projects that show evidence of students modifying ideas and trying again, changing direction to follow a new line of reasoning and following up on previous results with adjusted experiments. Some students may even find it helpful to set up a preliminary simplified 'test run' to see if their idea is worth pursuing on a larger scale. Students will therefore need to make all this clear in written reports, referring to 'previous work' and outlining changes made.
- **Randomisation of treatments**
  If appropriate to the experiment, students should be encouraged to look at randomised treatments. Simple random block designs should not be too overwhelming for students at this level. Students should also be guided to think about situations (eg. along a window sill) where random blocks might *not* work, and be encouraged to think of alternatives. This is also a good discussion point for students to get them thinking about effects of variables. Again, any randomised system should be clearly referred to by students in written work and displays.

- **Limitation of variables**
  For students at this level, maintaining a single test variable is probably the best way to approach an experiment. Some students may want to test the effect of more than one variable and it is suggested that they set up two experiments – either concurrent or separate – rather than attempting to test both in the one experiment.
  It will need to be obvious to judges that students have thought carefully about the effect of variables in their experiment and have developed a method that isolates the variable being tested from the others in a valid way.
  Independent variables (the ones being tested) are best if they are easily controlled – eg. can be easily measured, provided in controlled doses, do not fluctuate with time, etc.

- **Valid measurements**
  Some experiments provide data that is easier to collate, display, analyse and discuss than others. Students should be encouraged to think carefully about the kind of data they are going to end up with from their experiment and adjust the experiment if necessary to provide 'useful' data – ie. That will help them 'sell' what they have done and present a clear and reasoned conclusion. For this level of investigation, quantitative (numerical) data is probably better than qualitative, as it can be manipulated, graphed, displayed, etc.
  Students should also be encouraged to think about and show an understanding of accuracy and precision in measuring (and steer away from experiments that make accurate or precise measuring difficult).

- **Provide increments where possible**
  Many students start with just a direct comparison – "treatment" and "no treatment" – and often don't think of extending this to a range of treatments. Effects are often dependent on amount, therefore students may provide themselves with more useful data and material to discuss if they provide an 'increasing effect' in their experiment – eg. 'effect of water on seeds' moves from "water" and "no water" to no water, 5, 10, 15, 20mL of water.

- **In summary**
  Our suggestion is for students to make their experiments as simple as possible in terms of design, but as rich as possible in the scientific method concepts outlined above. Some experiments will lend themselves especially well to a rigorous scientific method and produce results that help display students' conceptual understandings. Other experiments may seem more 'interesting' initially, but inhibit students' ability to produce a valid, clear scientific method.

Reporting

The written report and display will be the way that students promote what they have been able to accomplish and the processes they have been through. It will be really important for them that they include as much of their scientific thinking in the report as possible (without it being too long).

The discussion especially will show how concepts have been understood and to what extent students have appropriated them for their work. The discussion will also show clearly how well students understand the experiment they have done and the results they have gained.

Further information:

Contact
Paul O'Halloran
Science Education Officer
UTAS – School of Agricultural Science
Cradle Coast Campus

Paul.OHalloran@utas.edu.au
Ph. 6430 4927 Mob. 0409 336 721 Fax 6430 4950