Minibooster 6: Progressing to level 6 and beyond

Understanding variables

Background

A pupil working at:

Level 4

- makes a series of observations and measurements and varies one factor while keeping others the same;
- recognises the range of variables involved in an investigation and decides which to control.

Level 5

- uses a sensible range and number of values of the independent variable;
- knows that sometimes variables cannot be easily controlled;
- selects and uses methods to obtain data systematically;
- describes and identifies key variables in an investigation and assigns appropriate values to these.

Level 6

- makes enough measurements or observations for the task with precision;
- explains the purpose of changing only one variable at a time;
- identifies which variables cannot easily be controlled and why;
- justifies whether the selected range and number of readings is appropriate;
- begins to link patterns emerging from measuring more than one dependent variable;
- uses and applies independent and dependent variables in an investigation by choosing an appropriate range, number and value for each one.

Level 7

- plans appropriate approaches and procedures, by synthesising information from a range of sources;
- uses quantitative relationships between variables;
- identifies key factors in complex contexts where variables are less easily controlled;
- decides whether conclusions based on a number of variables are valid (e.g. have these variables been controlled?);
- gives explanations of phenomena in which a number of factors have been considered;
- has some understanding of a randomised controlled trial.

To move pupils from level 4 to level 5

1. Ensure pupils are clear about the different types of variables.
2. Explain the relationship between the enquiry question and the variables identified.
3. Demonstrate the importance of using sensible quantities/values for the independent and dependent/fixed (controlled) variables.
4. Ensure pupils understand what constitutes a meaningful range and number of values for the independent variable.
5. Explain that not all scientific enquiry is fair testing, and that in some instances all the variables cannot be controlled.

To move pupils from level 5 to level 6+

1. Check that pupils understand and use the correct language for talking about variables.
2. Show pupils how the choice and range of variable might affect the quality of the conclusion drawn.
3. Show pupils how the choice of variable might affect the choice of graph.
4. Demonstrate how the choice of variable might affect the incidence or likelihood of getting anomalous results.
5. Show how the appropriate/inappropriate number of measurements can affect the precision of a graph.
6. Describe types of investigations where variables are less easily controlled.

Activities

1. Provide pupils with the titles of some investigations, for example, Worksheet 6(i) or use ones from your scheme of work. Ask pupils to discuss how they would measure each variable and then to give a possible prediction to show a likely relationship between the two.

   Show them how a numeric variable gives more precision; for example, '*fine sugar particles dissolve the fastest'* is less precise than '*fine sugar particles dissolve twice as fast as large ones'*, which is less precise than '*sugar particles less than 0.1 mm in diameter dissolve twice as fast as those over 0.5 mm in diameter'*.

   Can they now change any of the variables and predictions to make them numeric?

2. Provide pupils with a series of graphs and variables on separate cards, or ask pupils to suggest ideas for you to write as a list on the board. Ask pupils to match the variables to the appropriate type of graph. (See Minibooster 4 '*Making sense of graphical data*' for some different shapes of line graphs.)

3. Plot different graphs using the same data, to look at which type of graph helps to best answer the original questions.

4 Ask pupils to consider an investigation that could be carried out in the lab using living things (e.g. how much water do seedlings need?).

   Ask them to quickly identify the variables and how much of each they would use.

   Have they used more than one seedling for each value of the independent variable? Discuss the need to use more than one, because of biological variation (i.e. if they use ten seedlings, this is a representative sample). It is interesting to follow up what might be a good representative number and how you have to balance this against what is practical under the circumstances.

   Have they considered the less obvious variables like light or ambient temperature? For example, light or temperature levels in the laboratory will fluctuate during the day and night. This might be appropriate if the plants are to be grown outdoors but not so if they will be grown in a greenhouse.

5. Ask pupils to think about an investigation that would be done outside (e.g. does mowing affect the height of the dandelions?). Allow pupils to discuss how they would set this up and what the independent, dependent and fixed variables might be.

The independent variable is likely to be the *absence* of the mower, and the dependent variable the difference in height of the dandelions. The fixed variables such as the weather are more difficult to control, however. But if the areas being investigated are close together, then both are affected in the same way as the variables change.

6. Use Worksheet 6(ii) ‘*Selecting those variables*’. Extend the activity by asking pupils to look at the fixed variables and identify the degree of control they have over these variables, explain why it is hard to control them and how these variables might have to be taken into account when drawing any conclusions.

7. Explain what a randomised controlled trial is (see Appendix). Ask pupils to discuss why it is important:
   - to have a large sample;
   - to split them randomly;
   - that participants do not know whether they are receiving the treatment or the placebo;
   - to have a ‘blind’ or ‘double-blind’ study.

   Ask them to consider whether there could be more than two groups. For example, groups could receive different doses. Claims made by companies and individuals are often refuted because they have not carried out a randomised controlled trial.

Worksheet 6(i)

Titles of some investigations

- Does the size of sugar particles affect the time to dissolve?
- Does the type of wire affect the current flowing in a circuit?
- Does the type of soil affect the drainage?
- Does the amount of carbonate in stomach powders affect how quickly they work?
- Does the number of batteries affect the speed of the motor?

Worksheet 6(ii)

Selecting those variables

For each enquiry:

- draw a circle;
- write the dependent variable in the middle;
- list around the outside all the other variables that could make a difference to the dependent variable;
- highlight and label the dependent variable, the independent variable and the fixed variables;
- write a better title for the investigation.

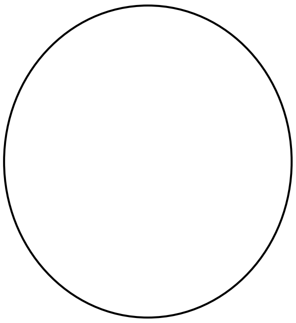
1. What affects how much salt dissolves?

Title for the investigation……………………………………………………………

2. What makes a difference to how tall plants grow?

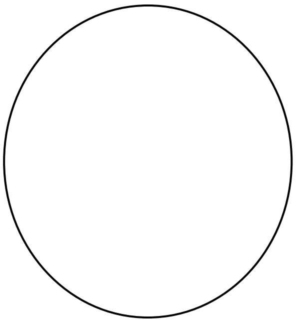
Title for the investigation……………………………………………………………

3. What affects the amount of evaporation of water from a dish?



Title for the investigation…………………………………………………….

4. What makes a difference to the length of a shadow?



Title for the investigation…………………………………………………….

Appendix

Background information on randomised controlled trials

These are particularly widely used in drug trials, but also in psychology and biology where there is variation in a number of the variables.

The person carrying out the trial will generally control one or two variables. For example, in testing a drug for stomach ulcers, they might decide to exclude any people who have had treatment for this in the past, and to use people between certain ages. A large group that fits the variables will be identified and randomly split into two groups. One group will be the experimental group and receive the treatment; the other will be a control group and receive a 'dummy' treatment, which is called a placebo.

However, nothing is quite so simple and there can be problems of bias from both the person carrying out the trial and the participants. *Researcher bias* happens when the person carrying out the trial 'finds' what they expect to find, even when it does not exist. For example, when asked to train a group of rats in a maze learning task, trainers who were led to believe their rats were 'maze bright' succeeded in training their rats faster than the trainers who believed they had 'maze dull' rats. In fact, both groups of trainers had similar rats.

If the participants in a trial are human, they also bring with them certain expectations and perceptions if they know the point of the trial. This has resulted in the development of the 'single-blind' and 'double-blind' study which can be used in different circumstances. In the single-blind study, sometimes the researcher, but more usually the participant, does not know the real purpose of the experiment (i.e. they are blind to the expected outcomes). In the double-blind study, procedures are used to keep both the experimenter and the participant in the dark.

For example, during the testing of a new drug in which two groups are to be compared, one group would be given the active drug and the other group a placebo. In a single-blind study, the participants do not know whether they are getting the active drug or the placebo, but the researcher does know. In a double-blind study, neither the participants nor the researcher knows who is getting the placebo and who is getting the test drug. This is revealed only after the data has been collected and analysed. In this way, the effects of the expectations of the participants and the researcher are fully controlled for.