Minibooster 2: Progressing to level 6 and beyond

Evaluating a practical technique

Background

A pupil working at:

Level 4

- can suggest improvements in their work, giving reasons;
- can describe and suggest how planning and implementation could be improved.

Level 5

- makes practical suggestions about how their working methods can be improved.

Level 6

- selects and uses methods to collect adequate data for the task, measures with precision using instruments with fine scale divisions and identifies the need to repeat measurements and observations;
- evaluates evidence, making reasoned suggestions about how their working methods could be improved;
- explains how approaches to practical work were adapted to control risk;
- explains how improvements to the planning and implementation would have led to the collection of more valid and reliable evidence and a more secure conclusion.

Level 7

- begins to consider whether the data collected is sufficient for the conclusions they have drawn;
- analyses findings and identifies possible limitations in primary and secondary data;
- selects and uses methods to obtain reliable data, including making systematic observations and measurements with precision using a range of apparatus;

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- evaluates the planning and implementation and explains how this could account for errors and anomalies and how inadequacies could be remedied;
- will suggest how the practical technique might have led to an anomalous result;
- identifies and explains the need for repeat or additional readings to improve the reliability of the data;
- can explain how the limitations of a measuring instrument can lead to error.

To move pupils from level 4 to level 5

1. Revisit work done on accuracy, reliability and anomalous results.
2. Ensure that pupils can identify odd-looking results (anomalies).
3. Look for practical and/or procedural reasons for anomalies.
4. Look for practical suggestions to improve procedure.
5. Decide whether the anomaly is an under- or over-estimate of what was expected.
6. Decide which suggested reasons for anomalies or suggestions for improvements best explain the results obtained.

To move pupils from level 5 to level 6+

1. Demonstrate the importance of using the correct piece of apparatus that will measure to the required degree of accuracy.
2. Explain how to decide when to take repeat readings or additional results.
3. Model how to evaluate a practical method to identify problems with variables or procedures that might lead to inaccuracies or unreliable results.

Activities

1. Use worksheet 2(i) '*Choosing apparatus*'.
   - Place each piece of equipment on a separate card. Pupils select the apparatus for each practical and explain why they made the choice.
   - Ask pupils to justify why they would **not** use the equipment they have rejected.

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Alternatively, give a list of practicals and ask pupils to decide on the most appropriate equipment, giving reasons for their choices.

Include less familiar practicals, and give pupils a range of apparatus to choose from.

2. Use Worksheet 2(ii) '*Dissolving salt*'.

   Ask pupils to do one of the following.

   - Write a plan for the practical and identify possible areas where errors could occur.
   - Plot graphs for group 1, group 2 and the average results on the same graph and compare them.
   - Add a third column of results where there are two anomalous results and then recalculate the averages. Discuss what difference this could make to the conclusions drawn.

3. Use the explanation cards on worksheet 2(iii) (adapted from the original Minibooster). Ask pupils to rank the explanations or use a diamond 9 to identify the most likely reasons for the anomalous result in the salt investigation. Emphasise the need to discuss **how** this might affect results. (Using the diamond 9, pupils prioritise the statements in the order 1, 2, 3, 2, 1, and then place them in the shape of a diamond. This allows equal second, third and fourth preferences.) Different groups then compare their rankings and try to agree a consensus of what they might need to do to resolve any differences in their rankings.

4. Carry out a practical task in front of pupils and ask them to identify where errors might occur that could lead to unreliable or inaccurate results. Discuss how the errors could have been avoided and the likely impact on the results.

5. Use examples of pupils' 'methods' from within the department and ask pupils to annotate with comments where errors could occur or whether there were problems with the plan. Were the correct variables chosen? Was there an appropriate range for the variable being investigated? Were there enough readings? Was the right equipment used?

6. Use examples of pupils' investigations to decide if increasing the number of readings or repetition of some readings was needed, and how this might improve the conclusions drawn.

7. Allow pupils to carry out some simple practicals in which different groups measure variables using different pieces of equipment and then compare

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results and identify the differences. Examples include measuring volumes using different-sized beakers, measuring cylinders or beakers; measuring mass using electronic balances to different numbers of decimal places; simple lever arm balances; domestic scales.

Some pupils may be able to calculate the percentage error at different readings. For example, a Newton meter that reads to 20 N and has a 0.4 N error.

At 20 N, the reading is +/− 0.4 N, which is 19.6–20.4 N.

The % error is $0.4 \times 100/20 = 2\%$ error.

At 10 N, the reading is 9.6–10.4 N.

The % error is $0.4 \times 100/10 = 4\%$ error.

The error is more significant at lower readings.

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Worksheet 2(i)

Choosing apparatus

Common practical	Choice of apparatus
Burning magnesium (gain in mass)	A balance that measures to the nearest 1 g, 0.1 g, 0.001 g
Measuring the distance when calculating the speed of sound	A 30 cm ruler, a metre ruler, a trundle wheel
Measuring the amount of food when doing food tests	Balance to the nearest 1 g, balance to the nearest 0.1 g, spatula
Measuring the effect of light on photosynthesis	Light meter (data logging) Light room compared with dark room
Measuring the amount of oxygen released during photosynthesis	Gas jar or test-tube
Measuring the amount of iodine solution when testing for starch	Beaker, 10 cm^3 measuring cylinder, teat pipette
Measuring the amount of sodium hydroxide required to neutralise 20 cm^3 hydrochloric acid	Beaker, 100 cm^3 measuring cylinder, 10 cm^3 measuring cylinder
Time for an athlete to run 100 m	To the nearest second, nearest 1/10th of a second, nearest 1/100th of a second

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Worksheet 2(ii)

Dissolving salt

Two groups of pupils wanted to find out how much salt dissolved at different temperatures.

This is what they found out.

Temperature in °C	Group 1 – mass of salt in g	Group 2 – mass of salt in g	Average grams of salt dissolved
30	1.7	1.7	1.7
40	1.9	2.1	2.0
50	2.2	4.0	3.1
60	3.3	3.3	3.3
70	4.7	4.5	4.6
80	6.0	5.8	5.9

- Identify the odd (anomalous) result.
- What do you think would be a more accurate result?
- If you use this more accurate result what would happen to the average?

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Worksheet 2(iii)
Explanation cards for salt practical

A few grains of salt were spilt.	The balance kept fluctuating by +/– 0.1 g.
The water came from different taps.	The 80°C water cooled by 10°C and the 30°C water by 2°C.
A few grains of salt had not dissolved before we added the rest.	The spatula used to measure the salt was not dried before use.
The same person did not stir all the solution.	We had to use a different balance part way through as there was a long queue.
The bulb on the thermometer broke so we used a different one – it looked just like the first one.	We measured the water using a 250 cm^3 measuring cylinder.

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