Minibooster 5: Progressing to level 6 and beyond

Describing patterns

Background

A pupil working at:

Level 4

- records their observations, comparisons and measurements using tables and bar charts and begin to plot points to form simple graphs;
- begins to relate their conclusions to patterns in data, including graphs, and to scientific knowledge and understanding;
- recognises that the presentation of experimental results through the use of tables, bar charts and simple graphs makes it easier to see patterns and trends.

Level 5

- uses line graphs to present data, interpret numerical data and draw conclusions from them;
- describes ways in which the presentation of experimental results through the use of tables, charts and line graphs makes it easier to see patterns and trends;
- explains patterns and trends in results and how this supports or negates any prediction made.

Level 6

- can give explanations for relationships between variables using scientific knowledge and understanding;
- can use a trend or pattern in results to make numerical predictions;
- analyses findings to draw conclusions that are consistent with the evidence, and uses scientific knowledge and understanding to explain them and account for any inconsistencies in the evidence;
- explains how the presentation of experimental results through the routine use of tables, charts and line graphs makes it easier to see patterns and trends.

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Level 7

- can give explanations for relationships between variables by linking scientific knowledge and understanding from more than one key idea;
- records data in graphs, using lines of best fit;
- can explain how they have made a numerical prediction based on the trend or pattern in results.

To move pupils from level 4 to level 5

1. Ensure that pupils can identify the variables and can describe a relationship between them.
2. Encourage pupils to identify and interpret patterns in data.
3. Demonstrate how to construct a table for the results that will help them see patterns.
4. Use Minibooster 4 to help pupils to understand how to describe patterns in graphs.
5. Show pupils how reordering data in a table can help patterns to become clearer.
6. Explain how to link the patterns in results to the prediction.

To move pupils from level 5 to level 6+

1. Ask pupils to give explanations for any patterns or relationships between variables, using scientific knowledge and understanding.
2. Encourage pupils to link scientific knowledge and understanding from more than one key idea (e.g. particles and energy) to help explain their pattern(s).
3. Ask pupils to find a mathematical trend or pattern in results and to use it to make numerical predictions that extrapolate or interpolate the current set of readings.
4. Encourage pupils to explain how they have made a numerical prediction on the basis of the trend or pattern they found in the results.
5. Encourage pupils to construct tables, charts and line graphs routinely to allow them to see patterns in data.

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Activities

All of the activities in the suggested teaching sequence from Minibooster 5: *Describing patterns* DfES 0196-2005 can be easily adapted to extend pupils to level 6+. This original Minibooster 5 is part of this document.

- **Activity 1** can be used in a shortened form, with the aim of ensuring that all pupils have a clear understanding of the correct vocabulary for describing relationships and are comfortable using it. Explain to pupils that living things often show trends because of the natural variation of individuals. A trend can be thought of as a general drift or tendency in a set of data.
- Use the PowerPoint® presentation entitled '*Pattern or not?*' In the 'Aspects of *How Science Works*' folder.
- To move pupils from level 5 to level 6+, each of the **activities 2**–**6** can be easily extended by adding the five suggestions listed above.

  For example, when using Worksheet 5(iii) '*Constructing a table*', you could add some questions such as:

  - How long will it take to fall from a height of 3.5 m?
  - What height do you think it was dropped from if it took 1.4 s?
  - Compare your answers with a partner's and explain how you worked these out.
  - Discuss the results with your partner and try to explain the pattern in the results. (What type of item might have been timed as it dropped?) Be ready to feed back to the class.
- Ask pupils to describe and discuss the implications from the 'patterns' in situations where things are less clear, such as a graph showing plant growth over time, or the volume of traffic at a junction during the day. Make sure that the following are explored with pupils.

  - Patterns here will not be exact or regular and may not be repeated. For example, would all plants show the same growth? Would traffic at the junction be the same every day?
  - It is more or less impossible to make detailed predictions.

  Share with pupils how easy it is to over-interpret or misinterpret patterns in data, for example, taking a small sample and generalising to a whole population.

  Another example might be to imply a cause from a correlation, as in the case of 'being cold leads to catching a cold'. Because you are usually shivery with a cold, there is the assumption that the shivery feeling is a cause of catching a cold, whereas it could just be a consequence.

  Or it might be that two variables are linked as a correlation whereas actually they are both the result of a common cause (e.g. number of

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wrinkles and increase in deafness: the wrinkles do not cause the deafness – both can be a result of old age.)

Ask pupils to think about some of the old wives' tales and whether a similar link has been made. These are some old wives' tales to try – but there are lots on the Internet and pupils could undertake some research to find out more!

- If your feet are colder than they were before pregnancy, you are having a boy.
- Do not eat cheese at bedtime, you will have nightmares!
- You can cure a nose bleed by dropping a cold key down your back.
- Ants signify bad weather when they are agitated.
- Warts can be removed by rubbing them with a peeled apple.

Suggested teaching sequence

The following activities could all be done in one lesson or divided into separate activities and spread out over more than one lesson.

1. **To ensure that pupils can identify the variables and be able to describe a relationship between them**

   - Ask pupils to discuss what they understand by the word *pattern* and establish with them that it means a regular or logical order or arrangement.
   - Look at the words *identify* and *interpret* with pupils. Discuss what they mean and whether they mean the same thing or if there are differences. You could give them definitions from the dictionary to discuss.

     Identify = recognise, establish or select by consideration or analysis of the circumstances

     Interpret = explain the meaning of; make out or bring out the meaning
   - Use Worksheet 5(i) '*Patterns and variables*' to help pupils understand that they need to identify the variables first. If you want to give pupils more practice at identifying variables that are changing, Use the autoshapes (Microsoft Word®) with different colours on the computer. Pupils will then have to see if the two variables are linked in any way (i.e. as one factor increases or decreases, what does the other factor do?). Not all have a pattern! Some pupils might like to have a scaffold: *As the __ increased, the __ increased, decreased or changed.*

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NB In most primary schools pupils will use the term 'factors' instead of variables. This difference in vocabulary needs to be made clear to pupils.

2. **To teach pupils to identify and interpret patterns in data**

Use Worksheet 5(ii) '*Pattern or not?*' to develop or consolidate pupils' understanding further. Table C refers to units of alcohol and the effects on a man. It might be an appropriate opportunity to stress to pupils the law with regard to alcohol consumption.

- Ask pupils what differences they might see between a table of results showing a pattern and one without a pattern.
- Use the worksheet to develop or consolidate pupils' understanding further. Draw out from pupils that it is easier to see a pattern if both variables are numbers (i.e. continuous) rather than one being categories (e.g. discrete).
- Also discuss that sometimes there might be an 'odd' or anomalous result; ask pupils to find examples in the tables on this worksheet. Ask them why they think the result is odd, what they would do if it was their experiment, and whether they can suggest a better result.
- Use unit 14, 'Describing relationships or patterns' from *AKSIS Investigations: developing understanding in scientific enquiry, p. 77* (available from the ASE ISBN 086-357-310X). There are four activities to help pupils describe the whole relationship clearly and precisely. Ensure pupils know the features that need to be included in their descriptions.

3. **To teach pupils how to construct a table for their results that will help them to see patterns**

- Use Worksheet 5(iii) '*Constructing a table*' to help pupils think more logically about what goes where on a table. Too often pupils are given a table format for their results with no explanation. Many struggle to construct tables because they have never been shown what goes where, and why! At the end of the session pupils can use some creative ideas to help them remember the important things about drawing tables.
- Use Worksheet 5(iv) '*Patterns in tables*' to help pupils see why the independent variable should go up in equal intervals, and that many results are needed to show a pattern. Some pupils may benefit from a brief demonstration of the investigation.
    - **Table 1** has only two results so you cannot be sure of any pattern. Nor can you predict further results.

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  - **Table 2** has more results but because the independent variable does not go up in equal steps, it is hard to see a pattern. Again, it is difficult to predict further results.
  - On **table 3** it is easy to see the pattern because the independent variable goes up in equal steps. This makes it a simple task to predict other values.

- Allow pupils to review previous tables they have drawn, or give them anonymous examples from other pupils. Let them discuss whether the tables have been drawn correctly.
- Next, ask pupils to describe any patterns in the tables using the following scaffold.

  The table shows that as the (independent variable) **increased** *then the (dependent) variable* **increased**, **decreased** or **changed**.

  Emphasise that the first variable is always the independent variable – the one they changed.
- To help pupils become more confident in their understanding of graphs, you can model the same process with a simple line graph. Pupils will benefit from having the table of results as well. Ensure they understand that the independent variable goes on the *x*-axis and that the dependent variable goes on the *y*-axis. If the line is not a simple straight line, then pupils need to reflect this in their pattern. For example, *My graph shows that when the temperature of the milk increased, the number of bacteria increased quickly up to 40°C and then decreased*. (Refer to Minibooster 4: *Science intervention materials* (DfES 0077-2004) and *AKSIS Investigations: getting to grips with graphs*, available from the ASE ISBN 086-357-3029.)

4. **To help pupils to be able to describe patterns in graphs**

   Use Minibooster 4 *Science intervention materials*, as above, and, in this series, Minibooster 4: *Making sense of graphical data* (00054–2008DVD–EN).

5. **To show pupils how the reordering of data in a table can help patterns become clearer**

   - Sometimes pupils cannot see patterns in data because of how it is presented, or they may see different patterns if the data are ordered in different ways. Use Worksheet 5(v) '*Does the order make a difference?*' to help them understand this.
   - Encourage pupils to make new tables with the two named variables, to see if there is a pattern. You might need to model the process for them initially. You may also need to explain some of the contexts if they are unfamiliar. Emphasise to pupils that they will need to think

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carefully about how they record any results or data, in order to show any links or patterns.

6. **To teach pupils how to link the patterns in results to the prediction**

   - When writing their conclusions, pupils need to describe patterns or trends in graphs or data, answer the original enquiry question and use the science they know, or can find out, to explain the conclusion. Many pupils will just restate their results, without describing a pattern, or will assert that their prediction was correct, even if the evidence suggests otherwise! Even if pupils do describe a pattern, they often fail to make a concluding remark to link that pattern to the original question. This is a skill that pupils need to learn.
   - There is some good guidance and an exercise for pupils to try in the *Literacy in science* unit, handouts 3.18–3.22 and video footage (DfES 0561/2002 and on the CD in *Resources to teach pupils about considering evidence*).
   - Unit 15, 'Relating evidence to scientific knowledge' page 84, from *AKSIS Investigations: developing understanding in scientific enquiry* (available from the ASE ISBN 086-357-310X) provides four activities that can be used with pupils to help them explain and interpret patterns in results in terms of scientific knowledge and understanding.
   - Use unit 7, 'Improving predictions by sketching graphs' page 47, from *AKSIS Investigations: developing understanding in scientific enquiry* (available from the ASE ISBN 086-357-310X). These two activities can be used to get pupils to sketch graphs of what they think will happen in the investigation. This is far more challenging! After they have completed their enquiry they can compare this graph with one drawn from their own data.
   - Model how you would write a concluding remark given the question, prediction and patterns found. Some pupils will benefit from being shown briefly how the experiment was carried out. Some examples are given in the table overleaf.

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Question	*Prediction*	*Patterns found*	*Possible conclusions*
What affects the brightness of a bulb?	I think the more bulbs you put in, the dimmer they will be.	Each bulb became dimmer as more were added. Increasing the number of batteries increased the brightness of the bulb. The higher the voltage of the bulb, the dimmer it was.	The number of bulbs, the voltage and the number of batteries can all affect the brightness of the bulb. This means that my prediction was partly correct because I only thought about changing the number of bulbs.
What makes an electromagnet stronger?	I think the biggest electromagnet will be stronger.	The more coils, the stronger the electromagnet. The more current, the stronger the electromagnet.	The experiment shows that the strength of the electromagnet depends on the number of coils and the strength of the current.
What makes a reaction go faster?	I think the reaction will be fastest with the strong acid.	More carbon dioxide was collected as the acid got more concentrated. Small marble chips produced more carbon dioxide. More acid produced more carbon dioxide.	I conclude that the reaction goes fastest when the marble chips are smallest, the acid is most concentrated and there is a greater volume of acid. This can be explained by …

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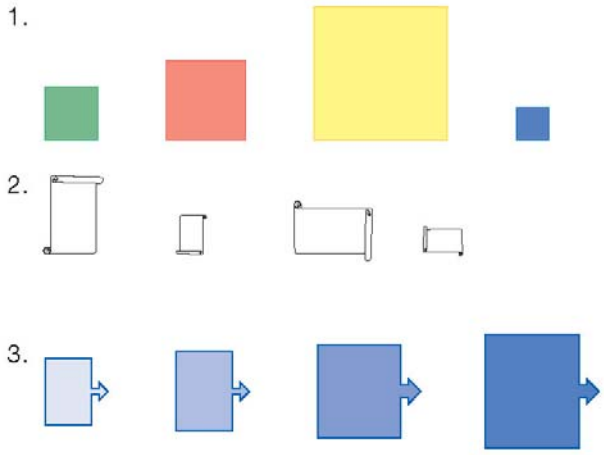
Worksheet 5(i)

Patterns and variables

Introduction



- Ask pupils what two things are changing in the examples above (i.e. what are the variables in the examples?). Then explain to pupils that sometimes the factors or variables can be linked; when this happens we begin to see patterns in data. For example, as one variable increases or decreases, the other one may increase or decrease at the same time.
- Show pupils a simple example, for instance different-sized bowls holding different amounts of cornflakes, or glasses holding different amounts of fizzy drink to illustrate this.
- Go through each of the examples to see if they show any pattern.

Main activity

Set up some sets of apparatus. For example:

- a series of beakers from large to small that are filled with a coloured solution that is darker as the size of the beaker increases;
- candles of different heights with stopwatches set to different times to show how long they would burn for;
- density blocks that are the same size but labelled with different masses;
- different amounts of marble chips in conical flasks with inflated balloons labelled with the volume of gas to show how much carbon dioxide was produced when acid was added;

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- different liquid fuels (same volume) labelled with the temperature they burn at;
- branches with different numbers of leaves and the number of insects collected from each one;
- electric circuits with different numbers of bulbs connected in series (power pack has the same voltage);
- different-sized measuring cylinders with the same volume of water in each (but the heights are different).

For each of the examples ask pupils to:

- decide which two variables are changing;
- decide if the two variables are linked in any way;
- describe and write down the pattern.

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Worksheet 5(ii)

Pattern or not?

Decide whether or not each table of results shows a pattern. Annotate each table to show what helped you decide.

1.

Height that stone is dropped from (m)	*Depth of the hole made in the sand (cm)*
0.5	1.2
1.0	2.8
1.5	3.5
2.0	4.0
2.5	4.6
3.0	5.7

2.

Material	*Does it conduct electricity?*
Copper	Yes
Graphite (carbon)	Yes
Tin	Yes
Coke (carbon)	No
Iron	Yes
Sulphur	No
Lead	Yes

3.

Units of alcohol drunk	*Effects on a man*
Up to 2	Loud and cheerful
2	Increased chance of an accident
2–3	Reaction rate slowed
3–5	Over the limit to drive
8–10	Speech slurred, uncoordinated
10–12	Cannot walk in a straight line

Comment [HB1]: Not sure the categories should overlap like this. Is the gap between 5 and 8 intentional? Shan – do you know where the original came from? - Sus

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4.

Time interval (minutes)	*Number of woodlice attracted to the rotting leaves*
0	0
5	22
10	45
15	45
20	67
25	94
30	91

5.

Time (minutes)	*Volume of gas given off (cm^3)*
0	0
1	17
2	26
3	34
4	39
5	41
6	42
7	42
8	42

6.

Speed	*Thinking distance (m)*	*Braking distance (m)*	*Total distance to stop (m)*
30 mph (48 km/h)	9	14	23
50 mph (80 km/h)	15	38	53
70 mph (112 km/h)	21	75	96

7.

Material	***Density (kg/m^3)***
Aluminium	2700
Copper	8940
Cork	250
Gold	19 320
Ice	920
Lead	11 350
Perspex	1200
Polystyrene	15
Steel	7900
Wood	650

8.

Angle of ramp (°)	***Distance travelled by car (cm)***
10	12
20	16.5
30	12.8
40	17.9
50	19
60	21.3
70	22.5

Worksheet 5(iii)

Constructing a table

1. Put the table below (or use one of your own) on the board or overhead projector as an example. Ask pupils some simple questions about what it shows.

Type of carrier bag	*Number of tins of beans it held*
White	8
Green	5
Yellow	12
Blue and white	9
Pink	11

- What is the table about?
- How do you know? What gives you the clues?
- How many bags were tested?
- What was the thing, factor or variable that was being changed?
- What is the name for the variable that we are changing?
- On which side of the table do we put the variable we are changing?
- What do the numbers tell us?
- What was the thing, factor or variable that was being measured?
- What is the name for the variable that we are measuring?
- On which side of the table do we put the variable we are measuring?
- Can we put the numbers in a different order? Explain your answer.
- Which is the strongest bag? Explain your answer.

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2. Repeat the exercise with a more complex table, such as the one below.

Height of drop (m)	***Time to fall (s)***
0.5	1.2
1.0	1.6
1.5	1.9
2.0	2.4
2.5	3.5
3.0	4.8

Ask similar questions as before.

- What is the table about?
- How do you know? What gives you the clues?
- How many tests were carried out?
- What was the thing, factor or variable that was being changed?
- What is the name for the variable that we are changing?
- On which side of the table do we put the variable we are changing?
- What was the thing, factor or variable that was being measured?
- What is the name for the variable that we are measuring?
- On which side of the table do we put the variable we are measuring?
- Why do we need to put units at the top of each column?
- What do the results tell us?

Finally, ask pupils to make a short list of things they need to remember when constructing a table for their own results, for example headings, units, independent variable on the left and dependent on the right. How could they remember that more easily?

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Worksheet 5(iv)

Patterns in tables

Introduce the activity by saying that pupils were carrying out a test to see if the mass of copper sulfate affected the time taken to dissolve. Explain to your pupils that you are going to show them the tables of results from three pupils, one at a time, and you want them to discuss whether they can see a pattern and explain the reasons for their answer. The question below highlights how easy or difficult it is to predict from the results.

Table 1

Mass of copper sulfate (g)	*Time to dissolve (s)*
5	3
30	18

How long do you think it will take 50 g to dissolve?

Table 2

Mass of copper sulfate (g)	*Time to dissolve (s)*
3	2
8	5
15	9
19	11
22	13
26	16

How long do you think it will take 50 g to dissolve?

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Table 3

Mass of copper sulfate (g)	*Time to dissolve (s)*
5	3
10	6
15	9
20	12
25	15
30	18

How long do you think it will take 50 g to dissolve?

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Worksheet 5(v)

Does the order make a difference?

1.

Day	*Temperature of classroom (°C)*	*Number of moving mealworms*
1	22	25
2	18	8
3	20	17
4	21	23
5	24	28
6	19	13
7	16	4

- Can you see a pattern in the results?
- Put the data in order of temperature, from lowest to highest.

Day	*Temperature of classroom (°C)*	*Number of moving mealworms*

- Can you see a pattern now?
- What is the pattern?

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2.

Name of animal	*Average length of gestation*	*Average birth weight of offspring (g)*
Dog (medium size)	9 weeks	250
Human	9 months	3500
Elephant	22 months	90000
Zebra	370 days	33000
Giraffe	444 days	53000
Mouse	20 days	1
Tiger	109 days	1000
Guinea pig	65 days	95
Sheep	5 months	6000

- Is it easy to see a pattern in the table?
- Reorder the table in different ways to see if there is a link between:
  - the size of the animal and the length of gestation;
  - the size of the animal and the birth weight of the offspring;
  - the weight of the offspring and the gestation time.

3.

Planet	*Distance from the Sun (millions of km)*	*Temperature of the surface (°C)*	*Time to orbit the Sun (years)*
Earth	150	20	1
Jupiter	778	−150	11.9
Mars	228	−40	1.9
Mercury	58	450	0.2
Neptune	4497	−230	165
Pluto	5900	−230	248
Saturn	1427	−160	29.5
Uranus	2870	−220	84
Venus	108	500	0.6

- Is there a link between the distance from the Sun and the temperature on the surface of the planet? If there is a pattern, describe it.

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- Is there a link between the distance from the Sun and the time taken to orbit the Sun? If there is a pattern, describe it.

4.

Element	*Atomic number*	*Melting point (°C)*	*Boiling point (°C)*
Aluminium	13	660	2470
Argon	18	−189	−186
Bromine	35	−7	59
Calcium	20	840	1484
Carbon	6	4200 (sublimes)	4800
Copper	29	1084	2570
Gold	79	1064	3080
Helium	2	−272	−269
Hydrogen	1	−259	−253
Magnesium	12	350	1110
Nitrogen	7	−210	−196
Oxygen	8	−218	−183
Silicon	14	1410	2355
Sulphur	16	113	445

- Can you find a link between the atomic number and the melting point?
- Can you find a link between the atomic number and the boiling point?
- Highlight metals with one colour and non-metals with another colour. Can you see a different pattern now?

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