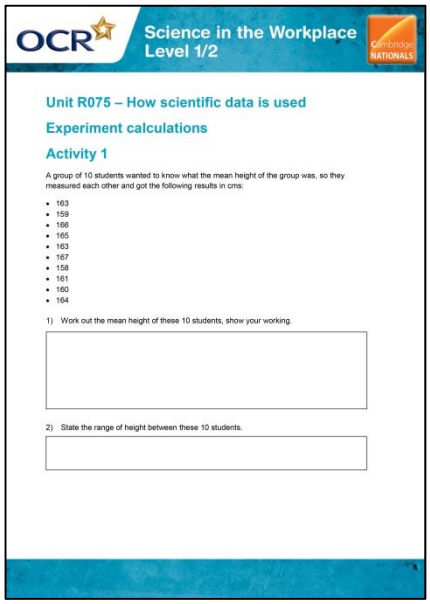
Unit R075 – How scientific data is used

Experiment calculations

Instructions and answers for teachers

The activities below cover LO2: Know and understand how scientists analyse and process information



Associated files:

Experiment calculations (activity)

Activity 1 – approx. 5 minutes

Activity 2 – approx.10 minutes

Activity 3 – approx. 15 minutes

Activity 4 – approx. 5 minutes

Activity 5 – approx. 10 minutes

This activity offers an opportunity for English skills development.

This activity offers an opportunity for maths skills development.

These activities provide a range of case study data from a number of experiments. Learners complete a set of questions for each case study, which include calculating the mean of each set of data, along with the range and percentage error.

Activity 1

A group of 10 students wanted to know what the mean height of the group was, so they measured each other and got the following results in cms:

- 163
- 159
- 166
- 165
- 163
- 167
- 158
- 161
- 160
- 164

1) Work out the mean height of these 10 students, show your working.

$$\frac{163+159+166+165+163+167+158+161+160+164}{10}$$

$$= \frac{1626}{10}$$

$$= 162.6$$

2) State the range of height between these 10 students.

Highest value – lowest value
=167 – 158
= 9

Activity 2

Some students wanted to find out the pH of rain water in their town. They went out and placed 10 collection containers in gardens along one street. When it had rained they collected their samples and brought them back to the laboratory where they used universal indicator to test the pH. They obtained the following results:

- 5.5
- 5.6
- 5.5
- 5.4
- 5.5
- 5.7
- 5.4
- 6.2
- 5.5
- 5.6

1) What is the range for this data?

Highest value – lowest value
= 6.2 – 5.4
= 0.8

2) Do you think this is reliable data? Why/not?

No – there is quite a large variation between the individual different values (a large range)
Yes – 6.2 could be considered an outlier which means the true range is 5.7 – 5.4 = 0.3 which is quite small and so the data is reliable

3) Calculate the mean for this set of data, show your working.

$$\frac{5.5 + 5.6 + 5.5 + 5.4 + 5.5 + 5.7 + 5.4 + 6.2 + 5.5 + 5.6}{10}$$

= 55.9/10 = 5.59 (5.6)

OR if the outlier has been taken out:

$$\frac{5.5 + 5.6 + 5.5 + 5.4 + 5.5 + 5.7 + 5.4 + 5.5 + 5.6}{9}$$

= 49.7/9 = 5.52 (5.5)

4) Are there any outliers in these results? If so, what would you do with them?

6.2 is considered as an outlier
This value should be taken out of the data or the reading repeated.

5) Do you think that this is a reliable method of collecting data on the pH of rain water in their town? Why/not?

No –the results obtained show quite a large spread, they should have done more than 10 tests, they should have repeated the tests at least three times, they should have used different streets, they should have done it at different times of the week or different seasons etc, they could have used a more accurate method of testing the pH – using indictor paper could be subjective.

6) What do you think they could have done to improve their investigation?

They should have done more than 10 tests, they should have repeated the tests at least three times, they should have used different streets, they should have done it at different times of the week or different seasons etc, they could have used a more accurate method of testing the pH – using indictor paper could be subjective.

Activity 3

A group of students were doing an experiment to see the effect of mass on the extension of a spring, they repeated each test three times, they got the following results 0g extension = 0cm, 0cm, 0cm, 50g extension = 2.4cm, 2.6cm, 2.4cm, 100g extension = 5.2cm, 4.9cm, 5.1cm 200g = 8.9cm, 9.9cm, 10.1cm, 400g extension = 20.7cm, 20.1cm, 20.4cm.

1) Draw a table to tabulate these results in. Leave a column to add the mean.

Mass (g)	Extension (cm) First repeat	Extension (cm) Second repeat	Extension (cm) Third repeat	Extension (cm) Average
0	0.0	0.0	0.0	0.0
50	2.4	2.6	2.4	2.5
100	5.2	4.9	5.1	5.1
200	8.9	9.9	10.1	9.6
400	20.7	20.1	20.4	20.4

Notes: ensure that:

- there are no units in the main body of the table
- All numbers are given to the same number of decimal places

2) Work out the mean extension for each mass and add it to the table. Use the space to show your working.

0g = (0+0+0)/3 = 0
50g = (2.4+2.6+2.4)/3 = 2.5
100g = (5.2+4.9+5.1)/3 = 5.1
200g = (8.9+9.9+10.1)/3 = 9.6
400g = (20.7+20.1+20.4)/3 = 20.4

3) Look at the range of data for each mass; do you think all their results are reliable? How can you tell?

The 0, 50, 100 and 400g tests are reliable as there is a small range between the data, but the 200g data has a range of 1.2 which is quite large, so this could be regarded as unreliable.

4) Are there any outliers in their results, if so which ones?

200g – the outlier is 8.9

5) What would you do with any outliers?

Exclude them from calculations and/or repeat the reading.

6) What impact would this have on your mean calculations, and therefore your conclusions?

If you excluded the outlier or repeated it, it would make the mean more reliable and a more representative value of the measurements, so the conclusion would be based on more accurate reliable data and so is more likely to be correct.

7) What do you think might have caused any outliers?

Human error (incorrect reading off the ruler, incorrect recording of results etc), equipment error, using equipment which is not precise enough, different people doing different parts of the experiment, environmental influences (someone knocked the table, breeze of wind etc).

Activity 4

A student measures a distance of 1 meter using a trundle wheel in the school field. Another student then uses a meter stick to see how accurately the trundle wheel has measured the distance. The student finds that the distance measured by the trundle is actually only 97cm.

1) Calculate the percentage error of the trundle wheel reading, show your working.

$$\% \text{ error} = \frac{100\text{cm} - 97\text{cm}}{97\text{ cm}} \times 100$$

$$= \frac{3}{97} \times 100$$

$$= 3.1\%$$

2) The two students repeat this procedure again, and find out that the actual distance measured this time was 105cm. What is the percentage error for this reading?

$$\% \text{ error} = \frac{100\text{cm} - 105\text{cm}}{105\text{ cm}} \times 100$$

$$= \frac{5}{105} \times 100$$

$$= 4.8\%$$

Activity 5

Three students decided to weigh an orange, an apple and a pear.

- The first student obtained the following results: orange = 77.4g, apple = 57.3g, pear = 67.4g.
- The second student weighed the same three fruits and got the following results: orange = 80.4g, apple = 50.3g, pear – 70.4g.
- The third student weighed the same three fruits and got these results: orange = 77.3g, apple = 57.3g, pear – 67.5g.

1) Do you think there are any errors in these results?

Students 1 and 3 have similar results and are therefore more likely to be correct. The second students have obtained results that are different to the others, this student has made some errors in their measurements.

2) If so, what type of error is there?

Random error – because it has been caused by human error (the other two students obtained similar data to each other).

3) Which students did this affect?

Student 2.

4) What might have caused this error?

Not zeroing the balance each time (for the orange and the pear as these have higher readings that the other two students), human error in reading the balance/recording results etc.

5) What could the students have done to avoid this?

Zero the balance each time, get another students to read the reading on the balance as well, and check what has been recorded etc.