CHAPTER 1

Working with scientific data

Have you ever wondered...

- which internet sites are trustworthy and which are not?
- why scientists sometimes use pie charts but at other times use column or line graphs?
- what the difference is between a mistake and an error?
- how to run a fair test?

LS

After completing this chapter you should be able to:

- identify problems that can be investigated scientifically
- use information from primary and secondary sources to predict results
- plan and conduct fieldwork and experiments
- identify ethical considerations that may apply to an investigation
- assess whether the planned investigations is fair, safe and is able to be performed using available equipment
- identify and explain the differences between controlled, dependent and independent variables
- construct and use tables, graphs, keys and models
- calculate averages and identify outliers in data
- analyse patterns in data using digital technologies as appropriate
- summarise data
- draw conclusions from primary and secondary sources
- evaluate the quality of the data collected and identify improvements.

AB 1.1

Chapter overview

In this chapter students will investigate primary and secondary data, conduct a variety of investigations, perform specific roles safely, apply simple numerical procedures such as calculating means, use scientific language, research from a range of sources and compare the reliability of gathered data with that from other sources. Students will also learn to use a recognised method to acknowledge sources of data, record observations and measurements using appropriate units, use, construct and analyse information from representations including graphs and tables, perform fair tests, measure and control variables, and describe safety and ethical guidelines.

Pre-prep

This chapter has a range of practical investigations for students to practise how to structure experiments, and a number of different experiments to start the year. Some practical investigations will require preparation. You may like to dip in and out of this chapter on an as-needs basis, or teach it up front.

Chapter duration: 3 to 4 weeks.

Pre-quiz

1 Describe a time when you have worked successfully in a team.
Student answers will vary, but probably will include when the team got along, and worked successfully together and had different skills.

2 Explain what a fair test is.
A fair test in science is an investigation where there are specific controlled variables.

3 Explain what the benefits of internet research are.
There is a lot of information available on the internet, although it is important to find accurate documents and websites. It is quick and easy to use.

4 Identify what type of science skills you are good at.
Student answers will vary. Help them to consider some of their strengths.

5 Explain why scientific research requires multiple investigations and experiments, and why something is not proven from one experiment.
Mistakes occur—it is important to minimise these. In one experiment there may be bias or personal choices that might affect the results, so several investigations need to be carried out.

6 Explain what controlled variables are.
Controlled variables are the variables in an experiment that are not allowed to change so the experiment can discover something about a different variable. They are controlled.

What's coming up

In Year 7 students will have covered basic information that introduced science. In this chapter this understanding of science is expanded. As students progress through the other chapters they should be reminded of the concepts of this chapter—how to collect, analyse and present data—as they are relevant to all future practical work.

PEARSON science 8 RESOURCES

Weblinks

A selection of weblinks and descriptions to support the development and application of content and skills in this chapter are accessible via your eBook.

Activity Book

1.1 *Knowledge preview* enables insight into student prior knowledge of key content and ideas.

Vocabulary preview

average
data
errors
first-hand data
human reflex
instrument error
mean
mistakes
outlier
parallax error
qualitative data
quantitative data
reading error
second-hand data
tare
zero error

science 4 fun

Internet reaction times

Background

Most students do not realise how fast or how slow they react to different questions or circumstances. Internet technology can help them find out. Ask students to do an internet search for reaction time activities using the key words 'reflex tester' or 'reaction time'.

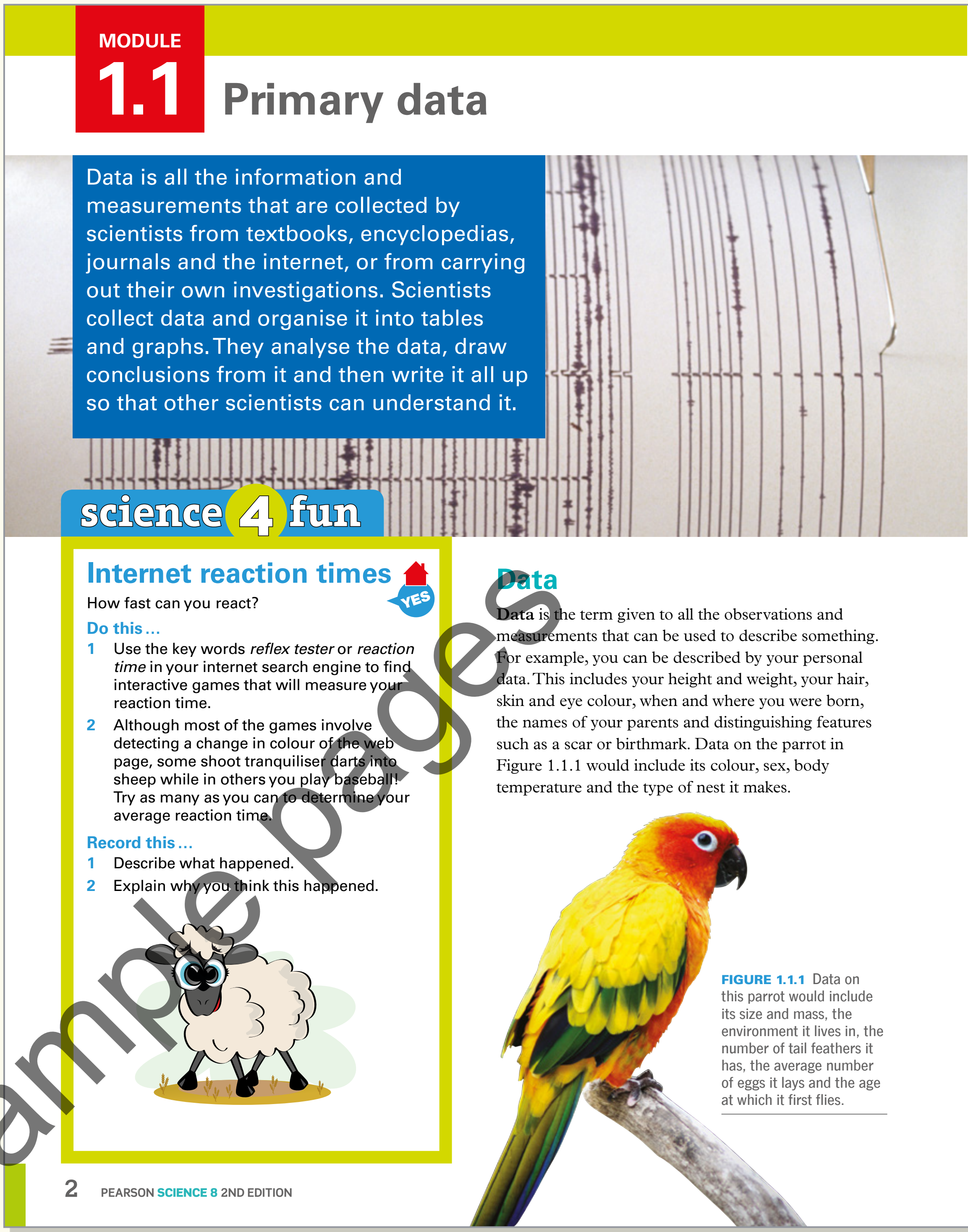
Hints and suggestions

■ **ENVIRONMENT DIFFERENTIATION**

In similar-ability pairs let students try a couple of different programs and compare the results. Ask them to record their times and calculate an average of their times. Also calculate the average reaction time for all the students in the class. Encourage students to understand that it is not a competition.

Possible results and looking forward

Students can practise calculating averages in this activity. They could also compare if they are faster on different types of activities and what circumstances affected their speed. Ask them to show these calculations mathematically and then summarise the information based on the comparisons.



MODULE 1.1

Primary data

Data is all the information and measurements that are collected by scientists from textbooks, encyclopedias, journals and the internet, or from carrying out their own investigations. Scientists collect data and organise it into tables and graphs. They analyse the data, draw conclusions from it and then write it all up so that other scientists can understand it.

science 4 fun

Internet reaction times

YES

How fast can you react?

Do this ...

1 Use the key words *reflex tester* or *reaction time* in your internet search engine to find interactive games that will measure your reaction time.

2 Although most of the games involve detecting a change in colour of the web page, some shoot tranquiliser darts into sheep while in others you play baseball! Try as many as you can to determine your average reaction time.

Record this ...

1 Describe what happened.

2 Explain why you think this happened.

Data

Data is the term given to all the observations and measurements that can be used to describe something. For example, you can be described by your personal data. This includes your height and weight, your hair, skin and eye colour, when and where you were born, the names of your parents and distinguishing features such as a scar or birthmark. Data on the parrot in Figure 1.1.1 would include its colour, sex, body temperature and the type of nest it makes.

FIGURE 1.1.1 Data on this parrot would include its size and mass, the environment it lives in, the number of tail feathers it has, the average number of eggs it lays and the age at which it first flies.

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As well as using the worksheets in the Activity Book, search the internet for worksheets related to measurement and reading scales to use for extra practise.

Learning strategies

Helpful hint

Mathematics

MI: Logical/Mathematical

In science, mathematics can often be a significant source of difficulty for students. For this reason, repetitive practise in taking measurements is particularly beneficial. Throughout this module, give students opportunities to read the scales on various instruments and apply their measuring skills.

Literacy strategy

Describing errors

MI: Verbal/Linguistic, Logical/Mathematical

Before reading the module, ask students to suggest why or how mistakes or errors might occur while performing experiments; for example, looking at a scale from an angle and therefore not reading it accurately, mixing the wrong chemicals, not starting the stopwatch quickly enough, having to estimate between two marks on a scale while measuring, or using equipment that is not accurate. After you have compiled a list, ask students to read the module and classify the mistakes and errors in the list according to the types of mistakes and errors outlined in the text.

Types of data

Much of the data you find will be measurements that are written as numbers with units attached to them. This type of data is known as **quantitative data**. Other data can only be described in words. This data is **qualitative data**. For example, data about Mt Kosciuszko in New South Wales is shown here and in Figure 1.1.2:

- Quantitative data includes:
  - coordinates (36°27'S, 148°16'E)
  - height (2228 metres above sea level)
  - average temperatures (-6°C in July, 21°C in January).
- Qualitative data includes:
  - Aboriginal name (Tar-Gan-Gil)
  - rock type (granite)
  - the animals that live there (wombats, spotted-tailed quoll, pygmy possum, corroboree frog, flame robin, mountain galaxia and wingless grasshopper)
  - wildflowers found there (alpine stackhousia, hoary sunray and snow beard heath).

FIGURE 1.1.2 Mt Kosciuszko is 2228 metres high and its main rock type is granite.

Data can also be classified according to where you obtain it from.

- **Primary data** is data that you or your **team** personally find out by running your own experiments, surveys and fieldwork. Any measurements that you take are primary data.
- **Secondary data** is data that comes from the work of other people. Secondary data includes the measurements and information that you find on the internet, TV, DVD and video, and in encyclopedias, textbooks, newspapers and magazines. Secondary data can also be obtained by interviewing experts.

AB 1.2 AB 1.3

Collecting your own data

You can generally trust primary data because you collected it yourself from experiments that you ran. If the data is wrong, then it's probably because you made a mistake.

Mistakes are things that can be avoided if you take a little more care. Mistakes happen when you spill material, use the wrong equipment (or the right equipment wrongly), wrongly read an instrument or incorrectly write or copy the measurement down. All these are obvious mistakes because they can be easily avoided.

Errors are not mistakes. Errors are small and unavoidable variations (changes) that occur naturally in measurements. Errors will always happen no matter how careful you are. This means that nothing is exact—even 'accurate' measurements have small variations and errors in them.

Some common forms of errors are:

- **parallax error**—your eye can never be exactly over the marking of a measuring device. Everyone looks at markings at slightly different angles, so everyone will take slightly different readings. Parallax error is caused when you read the instrument at a slight angle. This is shown in Figure 1.1.3.

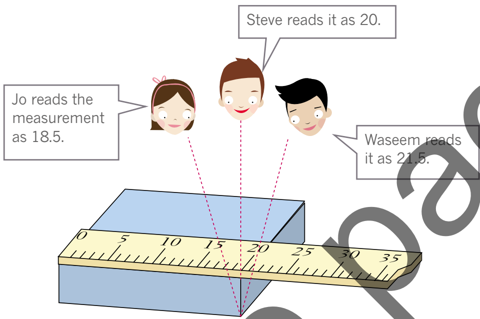

FIGURE 1.1.3 Jo, Steve and Waseem are all looking at the same measurement but at slightly different angles. Only Steve's measurement will be accurate. Jo's and Waseem's measurements will have parallax error.

SciFile

Discovery by mistake

Mistakes and accidents have led to some important scientific discoveries, including an artificial sweetener (saccharine) and the first antibiotic (penicillin).

PEARSON science 8 RESOURCES

Activity Book

1.2 *Spot the difference* covers comparison of pairs of organisms using Venn diagrams.
1.3 *Patterns in observation* challenges students to recognise and predict patterns.

Skills support

Pearson Skills: Science and Inquiry 1 has additional support for Designing an experiment.

Weblinks

Optical illusions

Reflex test

Using visuals

ENVIRONMENT DIFFERENTIATION

Lines on a ruler

MI: Bodily/Kinaesthetic, Logical/Mathematical

Ask students to look at their rulers. Some rulers have only centimetres labelled, while others will also have millimetres labelled. Point out the longer lines for centimetres and in some cases a mid-sized line for the 5 mm mark. In small mixed-ability groups ask the students to discuss and suggest reasons for the different ways rulers are labelled. Ask them why different materials are used for rulers.

Wooden rulers can chip and warp with age and the markings are often not very accurate, but they are not expensive. Metal rulers expand slightly with heat and contract slightly with cold, but they do not chip or warp and the markings are very accurate. Plastic rulers get scratched easily and can break, but clear ones can have useful extras such as a protractor.

Applying skills

Reducing parallax errors

MI: Bodily/Kinaesthetic, Logical/Mathematical

Set up measuring cylinders and beakers around the room, each labelled with a different number and containing a different volume of water. Ask students to move around the room, measuring the volume of water in each container. Have them record each measurement against the number of the container. When students have finished, invite them to compare their measurements for each container and account for any differences. Refer to Figure 1.1.3. Ask students to do the activity again and see if measurements improve. You could also use other measuring devices (e.g. thermometers, rulers, voltmeters) in this activity.

Research

Accidental discoveries

MI: Verbal/Linguistic, Logical/Mathematical

Read the SciFile 'Discovery by mistake' and have students in similar-ability groups find another example of a discovery by mistake. Ask them to share their example with the class.

CHECKPOINT

Students can now answer Module 1.1 Review questions 2, 4, 7, 8, 9, 16 and 17.

Inquiry activity

Ready, set, go!

MI: Bodily/Kinaesthetic, Visual/Spatial

Purpose: To identify human reflex errors and reinforce the need for repetition

Class time: 15 minutes

Materials: Stopwatches

Hypothesis: What errors might occur and how can we avoid them? Have students write a hypothesis before they start this activity.

PROCEDURE

1. Ask three students to volunteer to be runners (speed is not required).
2. Provide the rest of the class with stopwatches.
3. Divide the class into three groups and ask each group to record the time of one of the runners.
4. Have the volunteers run the length of a tennis court, using the baseline as the 'finish line'.
5. Record the time from each stopwatch for each runner and calculate an average time for each runner. Compare times.
6. After discussing errors, repeat the experiment with the timers in exactly the same position, and ensure that they agree on when the runner has reached the baseline (e.g. foot over, torso over). Compare the results to the first attempt.

QUESTIONS

1. Were the times in each group the same? If not, by how much did they vary?
   This is very unlikely. The variation depends upon student results.
2. How does the average time compare to the individual times for each runner?
   It is somewhere in the middle of the range of times.
3. Suggest reasons for the differences between the times recorded.
   The timers had different reaction times, used different stopwatches, positioned themselves differently at the finishing line, and had different definitions of when the runner reached the baseline.
4. Why do you think it might be important to have several people timing each runner in a race?
   Some timers will be slower and some will be faster at reacting. The average will be closer to the actual time.

- **reading errors**—measurements often fall between the markings of a measuring device. You need to estimate your measurement, and different people will make slightly different estimations. An example is shown in Figure 1.1.4.

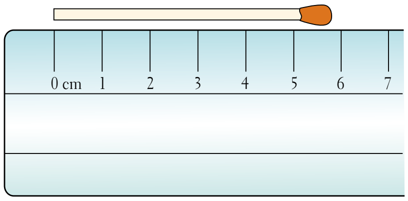

FIGURE 1.1.4 This match is not quite 6 cm long, but is it 5.7, 5.8 or 5.9 cm?

- **instrument errors**—sometimes an instrument may be faulty and will never give the right reading. Some instruments give correct readings only at certain temperatures and will give small errors if used at any other temperature. For example, a metal ruler expands when hot, pushing its markings further apart. As Figure 1.1.5 shows, this makes measurements taken on a hot day slightly smaller than those made on a cold day.

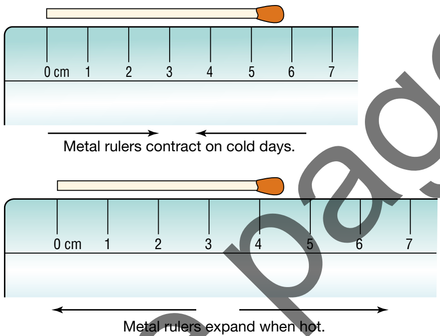

FIGURE 1.1.5 Metal rulers give different measurements at different temperatures. This makes the match appear 'longer' on cold days.

- **human reflex**—a stopwatch typically reads to one-hundredth of a second (0.01 second). The best human reaction time is around 0.11 second and so stopwatches are much more accurate than us. Everyone has different reflex times and so everyone will measure times slightly differently when using a stopwatch.

Prac 1 p. 9

- **zero errors**—an instrument such as a beam balance or electronic balance should read zero when nothing is placed on it. If it doesn't read zero, then everything you measure will be a little out and all measurements will have a zero error. Balances can usually be adjusted to read zero once more.

SkillBuilder

Tare

When you **tare** an electronic balance, you are resetting it to read zero when something like a beaker is placed on it (Figure 1.1.6). You can then add material without having to worry about the mass of the beaker because it has already been subtracted from the total mass.

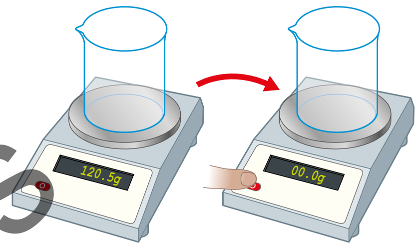

FIGURE 1.1.6 The tare button on an electronic scale resets its zero so that you don't have to worry about the mass of the beaker that is on it.

SciFile

A near disastrous mistake!

In 2009, an Airbus A340/500 jet was taking off from Melbourne with 275 people on board, bound for Dubai. It ran out of runway, scraped its undercarriage, shattered a landing light and only just missed the boundary fence. An investigation concluded that the pilots had mistakenly entered a wrong number into the on-board computer, making the plane 'think' that it was 100 tonnes lighter than it really was!

5. How is human reflex error removed in swimming and athletics races?
   Computerised systems using lasers or touch pads are used, and video evidence provides a backup.

PEARSON science 8 RESOURCES

Practical investigations

Prac 1, page 9 helps students understand reaction times.

Prac 2, page 10 demonstrates the use of repeated measurements.

Skills support

Pearson Skills: Science and Inquiry 1 has additional support for measuring length.

Pearson Skills: Science and Inquiry 1 has additional support for measuring mass.

Improving primary data

Errors always exist and each person in a team will probably take slightly different measurements of exactly the same quantity. Unless someone made a mistake then no one is wrong and everyone's measurement is 'correct'.

One easy way of improving the accuracy of your data is to repeat your measurements. For example, each member in your team could take the same measurement so that they can be compared and obvious mistakes eliminated. Mistakes in data can sometimes be obvious because they are very different from the other measurements. These measurements are known as **outliers** and should be ignored. Even if no mistakes were made, deleting outliers ensures that the remaining measurements are as accurate as possible.

You can then calculate the **average** (or **mean**) of the remaining data. The average will be the most accurate measurement of all because it doesn't include mistakes and has evened out all the small errors everyone made in their measurement.

Prac 2 p. 10

A little give and take

It is useful to write measurements with an estimation of how big the error might be. Scientists allow a little 'give and take' by showing the error as ± (standing for 'plus or minus').

Figure 1.1.7 shows the temperature on a thermometer. The exact temperature falls between the markings and a little guesswork is needed to measure it. It looks as though it should be about 27°C, but it could be a little higher or lower, perhaps by as much as 1°C. The measurement might be written as 27°C 'give or take' 1°C. Scientists write this as 27 ± 1°C.

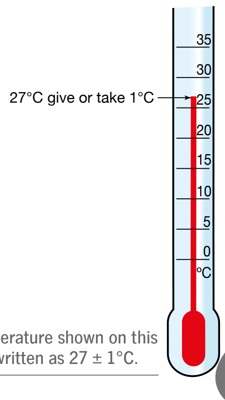

FIGURE 1.1.7 The temperature shown on this thermometer might be written as 27 ± 1°C.

SkillBuilder

Finding averages

1. Delete any outliers as these are the most likely to be inaccurate.
2. Add the rest of the 'good' measurements together.
3. Divide by how many 'good' measurements were taken.

Worked example

Finding averages

Problem

The members of a prac team each measured the length of the mouse's tail. Their measurements are shown below.

Team member	Length (cm)
Karen	8.1
Evan	8.4
Rebecca	7.9
Anna	8.2
Mark	8.5
Andrew	12.9

Solution

Thinking: Delete the highest and lowest measurements (outliers).

Andrew's and Rebecca's results can be ignored.

Add the rest of the 'good' measurements together.

Working: 8.1 + 8.4 + 8.2 + 8.5 = 33.2

Thinking: Divide by how many 'good' measurements were taken. Four 'good' measurements were taken.

Working: Average length $= \frac{33.2}{4} = 8.3$ cm

Note that no one actually measured 8.3 cm but this is the average and is the most accurate measurement based on the data collected.

Try yourself

Use the above procedure to calculate the average for each of the following sets of data.

1. 9, 10, 6, 13, 12, 10, 11, 15, 12
2. 0.72, 0.57, 1.02, 0.34, 0.74, 0.89

WORKED EXAMPLE ANSWERS
Finding Averages

1. 10.89
2. Delete 0.34 from data. Otherwise no outliers.

   0.808

Helpful hint

Delete or not delete?

MI: Logical/Mathematical

The worked example suggests that the lowest and highest measurements should be deleted and the rest should be averaged. This is not a true average, but it will help outliers. It is probably not worth doing if there is only one true outlier or no outlier. It could also affect the outcome. Encourage students to keep this in mind.

Worked examples

Average with no deletion

MI: Logical/Mathematical

1. Monday's highest temperature was 15°C, Tuesday's was 17°C, Wednesday's was 21°C, Thursday's was 16°C, Friday's was 19°C. What was the average highest temperature for the five days?

   = [15 + 17 + 21 + 16 + 19] ÷ [5]

   $= \left[\frac{88}{5}\right]$

   = 17.6°C

   = 18°C (to the nearest degree)

2. Sally has $15.60 in her piggy bank, Mia has $12.40, Kelly has $31.30 and Lin has $22.70. What is the average amount they have saved?

   = [15.60 + 12.40 + 31.30 + 22.70] ÷ [4]

   = 82.00 ÷ 4

   = $20.50

3. Sebastian has 3 dogs, Marilla has 6 parrots, Edmund has 2 cats, Mikhail has 2 budgerigars, Kim has 16 clownfish and Julie has 1 rabbit. What is the average number of pets?

   = [3 + 6 + 2 + 2 + 16 + 1] ÷ [6]

   $= \left[\frac{30}{6}\right]$

   = 5 pets

CHECKPOINT

Students can now answer Module 1.1 Review questions 1, 3, 5, 6, 10, 11, 12, 13, 14, 15, 18 and 19.

Assessment

Evaluate understanding

FORMATIVE ASSESSMENT

I have learnt…

MI: Verbal/Linguistic, Logical/Mathematical

Ask students to write ten sentences beginning with 'I have learnt…' and then write three questions they may still have about the content of this chapter. This allows variation in their answers, such as 'I have learnt to/how to/not to/about/why/that…' These sentences could use all or most of the terms listed in the Vocabulary preview at the beginning of the module.

Use the questions to address any misconceptions or gaps in their learning.

Reteach relearn

Identifying errors

MI: Visual/Spatial, Logical/Mathematical

Give students a range of diagrams or photographs showing different pieces of equipment used for measuring in investigations. Ask them to record the measurement shown on the diagram, including the relevant units, and identify and name one potential source of error for each.

Alternative assessment

Taking measurements

MI: Bodily/Kinaesthetic, Visual/Spatial

Set up a range of instruments around the room and ask students to read the measurement on each. Make this a quick task followed by a discussion about the actual readings (your version of the readings) and whether students agree with you. Ask them to give reasons. Instruments could include the following:

- ruler to measure a piece of string
- voltmeter in a circuit
- pH meter (analogue and electronic)
- measuring cylinder
- beaker
- thermometer (different types)
- barometer
- beam balance
- electronic balance
- burette
- bucket of water (one with measurements up the side).

PEARSON science 8 RESOURCES

Skills support

Pearson Skills: Science and Inquiry 1 has additional support for measuring temperature and working safely.

SkillBuilder

± errors in sets of data

You can find the overall ± error for your data by following these steps.

1. Find the average of the data.
2. Find the difference between the highest 'good' value and the average.
3. Find the difference between the lowest 'good' value and the average.
4. The ± error is the biggest of these differences.

Worked example

± errors in sets of data

Problem

In the previous Worked example, six students measured the length of a mouse's tail. Present this measurement as an average ± error.

Solution

Thinking: Find the average of the data.

Working: The average was 8.3 cm.

Thinking: Find the difference between the highest 'good' value and the average.

Working: 8.5 – 8.3 = 0.2

Thinking: Find the difference between the lowest 'good' value and the average.

Working: 8.3 – 8.1 = 0.2

The ± error is the biggest of these differences.

Both differences are the same, so the measurement can be written as 8.3 ± 0.2.

Try yourself

State the answers to the practice questions in the previous Worked example as average ± error.

Working with Science

HUMAN RIGHTS FIELD STATISTICIAN

FIGURE 1.1.8 Supporting Amnesty International's work

Data can be collected and analysed to answer many different questions. Data analysis gives us a way to find patterns, structure and meaning in complex sets of numbers. By applying scientific method along with statistics and mathematics to data, we can gain a better understanding of processes or events and use this understanding to predict outcomes.

Field statisticians in human rights organisations such as Amnesty International (Figure 1.1.8) do this as part of their job. They use statistical methods to answer questions about large-scale conflicts and human rights violations in places such as Lebanon, Sri Lanka, India and Colombia. Field statisticians collect and analyse data to measure rates of mortality (deaths), famine, violence and human rights violations in unsettled environments. Using scientific and mathematical knowledge, statisticians improve the monitoring, reporting and understanding of human rights issues. Their day-to-day jobs involve working in the field, collecting and processing data, developing software tools to analyse data, and applying the data to important questions about human rights issues. The knowledge gained from their work is helping to raise awareness and make positive changes for people living in areas where conflict and rights violations occur.

You might like this job if you enjoy solving problems, working in teams and travelling, while using your knowledge to address social issues. There are many opportunities to apply statistics in a variety of other interesting fields, such as health care and environmental science. A Bachelor of Science with a major in mathematics or statistics will give you the skills you need for these jobs.

Review

1. How do you think statistics can be used to help us to better understand social and environmental issues?
2. List three other fields where you think statistics will play an important role.

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WORKED EXAMPLE ANSWERS

± errors in sets of data

1. 10.89 ± 4.5
2. 0.808 ± 0.225

WORKING WITH SCIENCE ANSWERS

Human rights field statistician

1. Statistics can be used to organise, analyse and interpret large data sets. This gives us a way to find patterns, structure and meaning in complex sets of numbers. By using environmental and social data in this way, we can use this knowledge to understand why and how things happen the way they do, predict when they might occur and assess how to manage events (e.g. extreme weather events).
2. Possible answers:
   - Weather forecasting (meteorology)
   - Ecology
   - Demography (population studies)
   - Astronomy
   - Finance
   - Economics
   - Healthcare/epidemiology
   - Environmental science
   - Transport (e.g. train passenger numbers and travel patterns)
   - Immigration/emmigration
   - Agriculture
   - Marketing
   - Education
   - Psychology
   - Sports

MODULE

1.1 Review questions

Remembering

1 Define the terms:
  a primary data
  b tare.

2 What term best describes the following types of data?
  a that includes numbers and units
  b from the internet.

3 Which of the following statements are true and which are false?
  a All measurements are exact.
  b An average is also called the mean.
  c A mistake is the same as an error.
  d A measurement of 56 ± 2°C means that the measurement is somewhere between 54 and 58°C.
  e Human reflexes are always fast and accurate.

4 For Mt Kosciuszko, list three pieces of:
  a quantitative data
  b qualitative data.

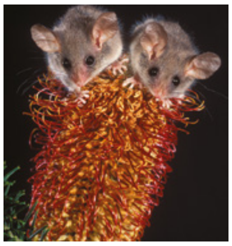

FIGURE 1.1.9 The pygmy possum is found through southern Australia, including Mt Kosciuszko.

5 What are the biggest and smallest values these measurements could be?
  a Elvir wrote down the length of an insect as 2.1 ± 0.1 cm.
  b Mang measured the temperature of the lake as 12 ± 3°C.

6 State what these measurements would be with a ± error.
  a The volume of a glass of soft drink was measured by Kim as 185 mL give or take 5 mL.
  b Iona measured the temperature that salt water boiled at as somewhere between 102 and 104°C.

Understanding

7 A scale is reading 0.1 g when there is nothing on it.
  a What errors might this bring to your measurements?
  b Describe two things that you could do to get accurate readings from this scale.

8 Explain why errors cannot be avoided.

9 Scientists generally take multiple measurements for the same quantity. Explain why.

10 Explain how the average of a set of measurements is calculated.

11 Metal rulers are inaccurate in extremely hot and cold temperatures. Explain why.

Applying

12 For each set of data below, eliminate the highest and lowest measurements and then calculate the average of the remaining 'good' measurements.
  a 39 mm, 61 mm, 38 mm, 42 mm, 41 mm, 30 mm, 40 mm
  b 25.3°C, 26.8°C, 38.1°C, 27.4°C, 21.2°C
  c 45 mL, 39 mL, 47 mL, 46 mL, 58 mL, 46 mL.

13 The time a ball took to drop down a 15.0 m cliff was measured by different members of a prac team. Their results are shown below.

Rebecca	1.61 s	Frank	1.74 s
John	3.23 s	Stavros	1.83 s
Christine	1.68 s		

  a Identify who most likely made a mistake.
  b Calculate the average drop time of the ball.
  c Identify the type of error that would have had the biggest effect on the results of this experiment.

1.1 ANSWERS

1 a Primary data: data that you or your practical team personally gathered by running your own investigations
  b Tare: a scale that has been reset to read zero when something has been placed on it

2 a quantitative data
  b secondary data

3 a False b True
  c False d True
  e False

4 For Mt Kosciuszko:
  a Quantitative data are its coordinates (36°27 S, 148°16 E), height (2228 m above sea level) and average temperatures (–6°C in July, 21°C in January).
  b Qualitative data are its Aboriginal name (Tar-Gan-Gil), rock type (granite), the animals that call it home (e.g. common wombat, spotted-tailed quoll, mountain pygmy-possum, corroboree frog, flame robin, mountain galaxias and wingless grasshopper) and the wildflowers found there (e.g. alpine stackhousia, hoary sunray and snow beard-heath).

5 a between 2.0 cm and 2.2 cm
  b between 9°C and 15°C

6 a 185 mL give or take 5 mL = 185 ± 5 mL
  b between 102 and 104°C = 103 ± 1°C

7 a It could bring a zero error or an instrument error, depending on whether the instrument is faulty or just not set at zero.
  b If there is nothing wrong with the scale, then it should be able to be reset to zero. This way, it should once again be giving accurate measurements.
  If the scale cannot be reset to zero, then you could subtract 0.1 g from every measurement you take. This assumes that the scale is constantly reading 0.1 g too high. If the scale is faulty, this will not work.

8 Errors are due to slight variations in instruments, insufficient markings on a scale, faulty instruments or human reflex. You cannot change any of these and are often unaware of them. They, therefore, cannot be avoided, regardless of how much care is taken.

9 If multiple measurements are taken for the same quantity, then obvious mistakes can be eliminated. Errors are reduced by averaging the 'good' results.

10 Delete the highest and lowest measurements. Add the rest of the 'good' measurements. Divide by how many 'good' measurements were taken.

11 Metal rulers expand when hot, making their markings spread farther apart. When cold, metal rulers contract, pushing the markings closer together. Any measurements on hot or cold days will be slightly inaccurate due to the change of spacing of the markings. However, in reality the expansion and contraction of a metal ruler (about 0.01% for every 10°C difference) will be extremely small.

12 a Eliminate 30 mm and 61 mm.
  Average = 40 mm
  b Eliminate 21.2°C and 38.1°C.
  Average = 26.5°C
  c Eliminate 39 mL and 58 mL.
  Average = 46 mL

13 a John's result is very different from all the other results. He is the team member who most likely made a mistake.
  b Eliminate the smallest and highest results (Rebecca's 1.61 s and John's 3.23 s) and calculate the average of the remaining three 'good' results:
  Average = 1.75 s
  c The investigation involves human reflex at the start and at the end when starting and stopping the stopwatch. Hence, human reflex is likely to be the most important error.