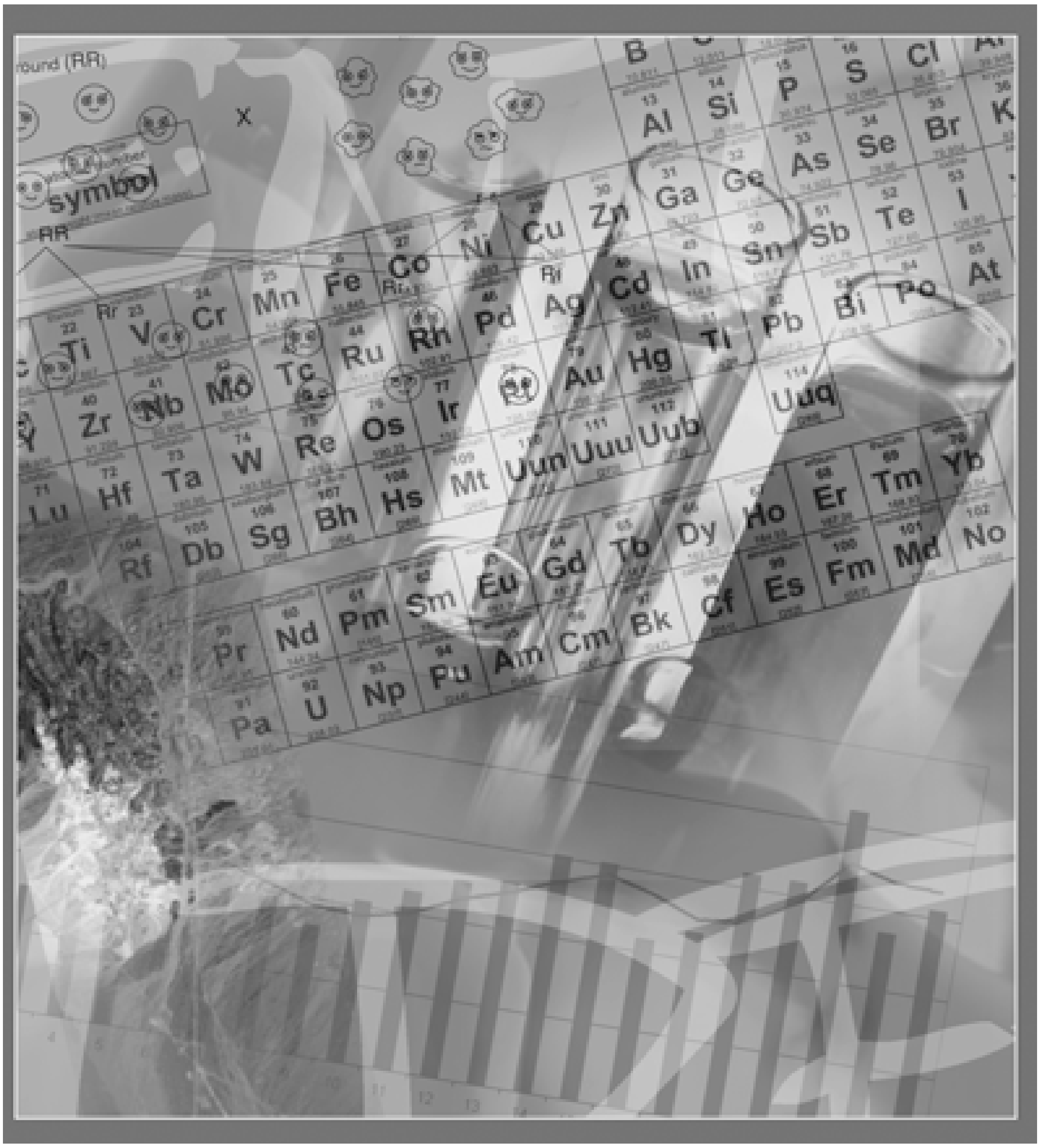
Student research project

Collecting data and fair testing



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Contents – Collecting data and fair testing

Introduction

This part will help you learn about how you can collect different types of data and design your experiment.

The data you collect will be **first-hand** and from **secondary** sources. Secondary data comes from other people's research. First-hand data is the information that you find out through your investigations and measurements. Your investigation must collect accurate and reliable data.

This part will also help you to design a fair test.

You should:

- show information in your logbook that you have collected from secondary sources (including accurate references to these sources)
- show your plans in your logbook of how to collect and record observations of your own data
- identify independent, dependent and controlled variables in your investigation
- organise the materials you need to perform your research.

Information - secondary sources

Finding out what is already known about a research question is a very useful activity. Remember that it is impossible to find out ‘everything’ about your problem, so you must limit yourself to a few main ideas or keywords that will keep you on track and to your timeline.

Secondary sources

Libraries, international organisations, the Internet, institutions and people are rich sources of information. One book or newspaper article will not provide all the information you need. You must consult a variety of sources.

Before you begin a search for information, you have to know exactly what you want to find out.

In the library

You may have access to a wide variety of resources in a library. As well as books, there are magazines, journals, audiotapes, CD-ROMs, databases, newspapers and videos as well as access to the Internet.

When you go to a library, talk to a librarian. Tell them about your project and ask them to guide you to resources that could be of use to you.

Organisations and institutions

There are many organisations that can provide you with advice and information. The ones you contact depend, of course, on your research problem.

People

Never underestimate the value of talking with people. It will surprise you how much some people know about all kinds of things.

Often it turns out that even if they don't have the answers to questions that you ask, they know where to get the information. This is just as important as knowing.

You could talk with your family, friends, neighbours, local business operators, people in trades, shopkeepers, farmers, firefighters, councils workers – anyone you know who will talk to you.

The Internet

The Internet is a rich and varied source of information. However, it is very easy to spend a lot of time and find little relevant information! Use your keywords as a guide to limit your searches.

Other sources

You may find other sources of information, such as television, radio, CD-ROMs or even movies. Keep asking yourself, 'Where could I find out more?' and 'How could I use this piece of information?'

If you keep thinking about your project, you'll probably find lots of information. (In fact, most students end up with too much information! Then they have to use other skills to sort out which information is important and useful, and which is not.)

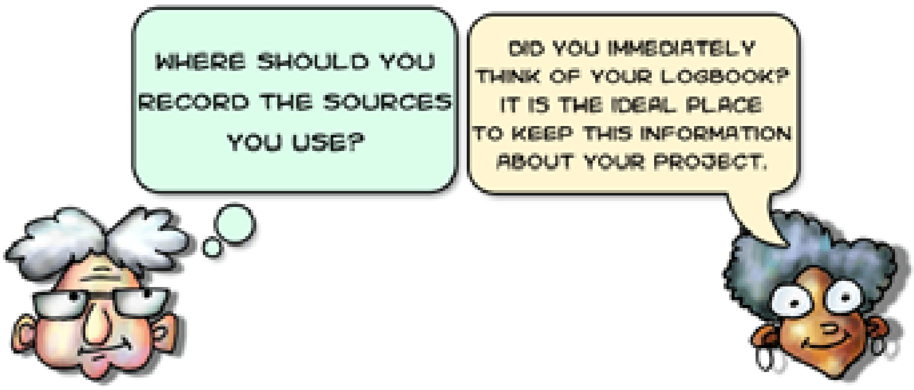
Have you found any other resources you may be able to use? List these in your logbook.

Go to the exercises section and complete Exercise: Finding information.

Making a reference list

It is your responsibility to keep a record of the source of any information that you use. There are several reasons why this is important.

- The work may belong to someone else. Copyright laws protect the owner's rights to this information. You must acknowledge the source of your information, especially if you have copied a table, graph, diagram or part of someone else's work. Some owners have restrictions on how their work can be used. Don't assume that because it is on the Internet you are free to copy.
- Someone (maybe your teacher or another student) may wish to check the accuracy of the information in your project. You must acknowledge the information which belongs to someone else and identify the source so that it can be examined.
- You may wish to refer to the source again. You'll find it very hard to find if you can't remember what it is!
- You need to list sources you use in the 'References' section of your project report.
- You must cite the owner of anything that you copy next to the work.



What to do:

1 Turn to the back of your logbook.

2 Write the heading, 'Resources', at the top of the first page.

3 Write each one of the following headings equally spread on the page.

- Books
- Magazines and pamphlets
- People contacted
- Websites, CD-ROMs, video
- Organisations and institutions.

Alternatively use the space supplied in the scaffold of your logbook.

Whenever you use a book, pamphlet, magazine or CD-ROM, watch a video, talk to someone or visit a website to gather information for your project, record it in this section of your logbook. This information will form the reference list (or bibliography) for your project.

It is important that you accurately record the information about each source. There are conventions (standard ways of doing things) for citing (identifying) each kind of source.

For books:

- author's surname and initial(s)
- title of book
- place of publication.
- publisher
- year of publication

For example, Womack JP, Jones DT. The Machine that changed the world, New York: Macmillan, 1990.

For journals and magazines:

- author's surname and initial(s)
- title of article
- title of journal or magazine
- year of publication
- volume number
- issue number
- page numbers.

For example, Williams A, How to Effect Change. Education Monographs 1998, 5 6:2–5.

For pamphlets:

- department/organisation or author
- year of publication (if available)
- title of pamphlet (in italics)
- name of publisher (which may be the department/organisation)
- place of publication.

For example, Australian Photonics, *The How, What and Why of Optical Fibres*, Australian Photonics, Sydney

For websites:

- author
- date (when was the site created or reviewed)
- name and place of sponsor organization
- date website viewed
- the exact address (URL) that appears at the top of your browser page

For example,

Learning Materials Production, 2004, NSW Department of Education and Training, Sydney, viewed 7 March 2005,< www.lmpc.edu.au/Science/junior_science/jsc5unit_10_2/project.htm>

For people:

- name
- some identifying or descriptive information.

Do not include personal details such as an address or telephone number, to protect the person's privacy. However, you could include the person's professional title and workplace details if appropriate.

Choosing relevant information

Some students think that all they need to do is copy out any information they find that contains their keywords. But they are wrong!

- Skim through the information, looking at headings and graphics.
- Scan the information to look for keywords, useful points and explanations.
- Use your own words to write the important information that you find (into your logbook, of course). Often you need only one or two sentences from several pages or even about an entire book.

It is often a good idea to write the information in point form. Then, when you use the information to prepare your own report, you will automatically be making sentences that are your own.

Go to the exercises section and complete Exercise: Making a reference list.

Make sure that you have started to look for information for your research project.

Making first-hand observations

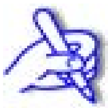
When you make observations you are gathering first-hand information. By the end of this lesson, you should be able to:

- distinguish between a **qualitative** and a **quantitative** observation
- use a variety of ways to record observations.

Types of observations

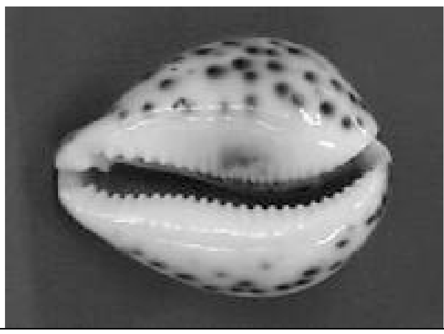
There are two main types of observations that can be made:

- qualitative (or descriptive) observations
- quantitative observations of features that can be counted or measured in some way.



Making careful observations

Consider the different kinds of observations in the example below. Write the headings, 'Qualitative observations' and 'Quantitative observations' in the correct boxes on either side of the shell photograph.

• white with dark spots • pointed at one end • long serrated opening • very shiny surface		• 6 cm long 4 cm wide • centre opening 0.5 cm • mass of 46 g

The box on the left has qualitative observations whereas the box on the right has quantitative observations.

All scientific observations should be unbiased and accurate. They must be recorded neatly and in an easy-to-understand form.

Qualitative observations

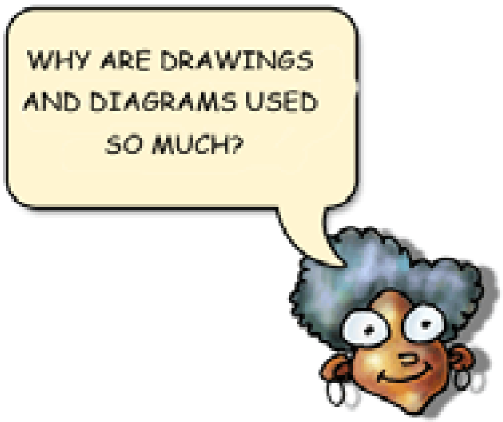
Qualitative observations may be recorded in the following ways:

- drawings and diagrams
- photographs
- recordings (audio or video)
- written descriptions.

It is important that what is recorded is what is actually observed and not an interpretation.

Drawings and diagrams

Look through any science textbook. There are always a lot of drawings and diagrams. What are they used for? They are used to communicate ideas, relationships, show experimental set-ups and other things that are not usually part of everyday life. For example, the parts of a flower would be shown in science as a diagram.



Here are some reasons. Diagrams and drawings:

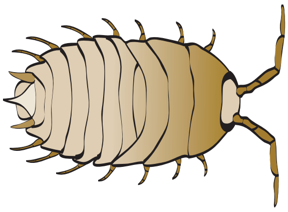
- contain a lot of information
- are often easy to understand
- are a very economical way of describing things that would otherwise require a long and complicated written description.

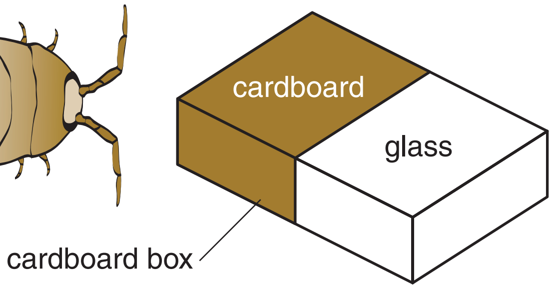
To draw a scientific diagram you need the following equipment:

- a HB pencil
- a ruler
- an eraser
- a pencil sharpener
- several sheets of white unlined paper.

Before you put pencil to paper, you need to decide what it is that you are trying to show in your diagram. The examples that follow show you some of the different purposes that diagrams have been used for.

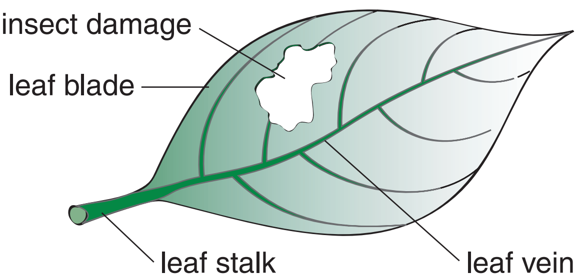
The student studying the behaviour of slaters drew the following diagrams in her logbook. The first was a drawing of a slater and the second was the experimental set-up.



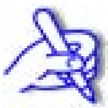


The student decided to only use the diagram of the experimental set-up in the final report.

Another student, Susan wanted to describe the location of insect damage on a leaf. Her drawing is shown below.



These diagrams would be useful in a final report. Do you think that a diagram would be a useful way to show equipment or observations in your project?



Drawings and diagrams

In your logbook, complete a neat, labelled diagram of one aspect of your project.

Photographs

Sometimes a photograph is the best way to record an observation. For example, you might use a photograph if you want to record the following observations:

- colour of an indicator in different solutions
- a change in colour of a chemical solution
- different plastic bags after a month's burial.

The photograph shows an indicator in solutions of varying pH.

Decide if you will need to take photographs for your investigation. Describe your thinking in your logbook.

Recordings

You may have access to a video camera or an audio recorder. These can be useful tools for your research.

Movement, colour and sound are all part of a video recording. This is sometimes the best method of recording an observation. For example, if you were to research the behaviour of water birds, a video would describe their feeding habits and mating behaviours very clearly.

Sometimes, particularly if a person uses lots of actions when they speak, videotape is a good way to record an interview.

Sometimes the research you are doing focuses on sound rather than a visual element. If you decide to record all or part of your research observations as audio, make sure that you also say the time, date, subject and any other important information.

Interviewing

Interviewing means asking people questions to find out about their experiences, opinions, values and so on. Interviews are more flexible than surveys because you can ask additional questions.

Like other methods of data collection, interviews have advantages and disadvantages. Each of these has to be weighed against your research problem to decide if interviews would be a suitable part of your project.

Here are some factors to consider:

- Plan your introduction before the interview. You must explain who you are, what you are doing and what you want to find out.
- All questions should be prepared in advance.
- Draft your questions, then interview people you know in places you know, to build your confidence and gain experience.
- Data can be recorded by various means. For example, responses may be written as a summary, in tables, or by video or audio.
- Since the people you are interviewing are doing you a favour, you must be sure that you are thankful and appreciative of their time spent with you. It may be necessary to arrange, in advance, an interview time and place.

Here is a check list that you can use when you conduct an interview.

Tick the box when you have:

- [ ] investigated background information before the interview
- [ ] prepared your questions in advance
- [ ] prepared a method of recording the information collected in advance (for example, organised a tape recorder, drawn spaces or a table for answers)
- [ ] listened to and recorded the person’s answers carefully
- [ ] thanked the person who granted you the interview.

Written descriptions

A written account may be the best and simplest method to record your observations.

Writing descriptions is a skill that you learn by practising. Here is an example of a scientific description to remind you of some important features.

uses technical terms

The crab has a blue carapace, with eight legs and two claws. Its legs and claws are both jointed and the claws are larger than the legs. The crab has two small eyes at the front of its body.

uses referral words

uses impersonal language

uses present tense

The report style shown above is used in many descriptions. But if you are describing something that has happened (rather than something that keeps on happening), write in past tense.

Use your logbook to write a description of things that you have observed during your project.

Quantitative observations

Information recorded as numbers is called quantitative data. This involves counting and/or taking measurements during your research.

There are several ways to record this type of data. Often it is recorded in a series of steps.

Raw data means the measurements you actually made. This data should be jotted down in your logbook. It may be unstructured or you may have planned a format, such as a table, in which to record your observations.

Presented data may be raw data that has been changed by performing calculations or shown in a different form. Some common ways to present data are:

- tables
- graphs
- computer spreadsheets or databases.

Graphs and spreadsheets will be covered in detail in another section, *Graphing data.*

Using tables

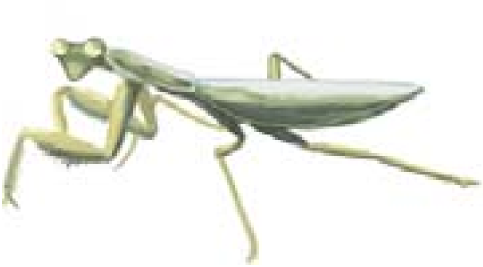
Data from quantitative observations is often recorded in tables. Trends in the data may be more easily seen. A blank space in the table makes it obvious if you miss a measurement. Sometimes calculations such as totals, averages and percentages are included in the table grid.

Here is an example of a simple table. Notice that the table has a heading, and each column has its own heading and units.

Distance travelled over time

Time (s)	**Distance (m)**
0	0
1	5
2	20
3	44
4	60

A researcher studied praying mantises to investigate the relationship between the length of praying mantis's legs and the height it can jump. The researcher also wanted to show the average length of a praying mantis's leg and the average height it could jump.



Praying mantis

The measurements taken and the researcher's calculations are shown in the following table.

Praying mantis leg length (cm) compared with jump height (cm)

		Jump height (cm)				
Praying mantis	**Leg length (cm)**	**Trial 1**	**Trial 2**	**Trial 3**	**Total**	**Average**
1	34	61	77	66	204	68
2	23	56	67	78	201	67
3	31	56	65	38	159	53
4	40	87	54	15	156	52
Total	128					239
Average	32					60

This table shows the raw data for the jumping trials and it also shows the calculated values that the researcher would use to draw conclusions. (The researcher found that leg length does not help you to predict how high the praying mantis can jump.)

Once again, notice the features of the table.

- All the lines in the table are ruled straight.
- The table has a heading to describe the information it contains.
- Each column and row of the table has its own heading.
- Headings that describe measurements include the unit of measurement.

Often when creating a table for an investigation, the two variables that are recorded are the dependent and the independent variables for the experiment. The convention is to place the independent variable in the first column and the dependent variable in the second column.

Drawing good tables takes practise.

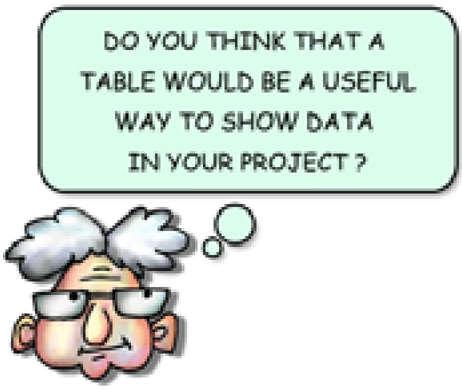
A tally sheet is another example of a way to record data. Tally sheets are useful if you are counting large numbers, e.g. slaters under a log.

For example, a researcher was interested in researching the number of birds that visited a dam at different times of the day. Here is his tally sheet with his observations.

Number of birds visiting the dam at different times

Time	Tally of birds visiting the dam
7 am	𝍸 𝍸 𝍸 /
8 am	𝍸 𝍸 ////
9 am	𝍸 ////
10 am	𝍸 //
11 am	///
12 pm	

Go to the exercises section and complete Exercise: Making observations.



Use this check list to make sure that your tables are drawn correctly.

- ☐ The title clearly sets out the purpose of the experiment and includes the dependent and independent variable.
- ☐ The first column is for the independent variable.
- ☐ The second column is for the dependent variable.
- ☐ Numbers entered correctly, the units are included in the column headings

By now, you should have formulated a hypothesis and collected some information from books, the Internet, other people and so on. Now, you need to begin to think more carefully about the hands-on, or practical, part of your project.

How will you collect and record data?

You may have decided that your problem requires you to collect data, for example by making some measurements. Data can be collected in a variety of places:

- in the field (outside, at the research site you are investigating)
- in the laboratory (from experiments you set up).

The data you collect could be simple observations and/or measurements using scientific or homemade equipment.

What kinds of data do you need to collect in your investigation? List the ways you will record and/or present your data in your logbook.

You should have listed more than one method of data collection or presentation. It would be unusual to use only one of these ways of presenting data in a scientific report.

Designing your investigation

When you are designing an experiment, you must consider all the things that may alter your results. These things are called variables.

Variables

All investigations have many variables. A controlled experiment tries to keep as many of the variables the same, or constant, throughout the experiment so that they do not affect the results too much.

But there is at least one variable in the experiment that you do not keep constant. This is the variable that you are testing. It is known as the **independent variable**.

The independent variable

The independent variable in an experiment is the one that you plan to change. It is also known as the **manipulated variable**. For example, if you wanted to test the amount of lather or bubbles of soap in water, you could use water at different temperatures. You could also use water from different sources, such as rain, the sea, a dam or bore. In this example, the temperature and the type of water are both independent variables. They are the variables that you are intentionally changing or manipulating.

To keep results as simple as possible, it is a very good idea to use only one independent variable in any experiment. So you would perform two different experiments in this investigation of soap and water. One experiment would find out the effect of different water temperatures, and the other would find out the effect of different types of water on the amount of bubbles produced.

You decide what the independent variable will be so that you can find out its effect on something else. It will cause something else to change that you will measure. This 'something else' is the dependent variable.

The dependent variable

When you change one variable during an experiment, another variable may change in response. This variable is called the **dependent variable**. Another name for this variable is the **responding variable**. For example, the variable that responds to changing the temperature of soap and water is the amount of lather or bubbles. So, amount of bubbles is the dependent variable.

But, you can only be sure that the dependent variable is changing because of the independent variable if all the other variables in the experiment are controlled. These are called the **controlled variables**.

Controlled variables

Controlled variables are kept constant throughout the experiment. For example, in the soap versus temperature experiment, the researcher would keep the following variables constant: the amount of water, the amount of soap, the amount of shaking.

This means that for every trial, you would have the same amount of water, soap and shaking.

As you can see, there are usually a lot of variables that need to be controlled. If these are not controlled, or kept the same during the experiment, then they may affect the result of your experiment. For example, if the amount of soap was different or you had different amounts of water then the change in the number of bubbles may not be related to the change in temperature.

The control

A controlled experiment has a **control**. A control is as close as possible to the normal situation. It is used as a standard against which the experimental results are judged. Some experiments do not have a control.

Good design

To design a good experiment, you have to know which variable you are changing, and which variable depends on these changes that you make.

In other words, you have to know which is the independent variable and which is the dependent one. You must also control all other variables.

You also need to know which variable is which to present your observations in a scientific report. When you are recording the results of a **controlled experiment**, measurements of the independent variable are usually put into the first column. Results for the dependent variable are in the second column. This is shown in the table below.

The student measured the water temperature as a particular fuel burned. In this case, time is the independent variable and the water temperature the dependent variable.

Independent variable → Time (s)

Dependent variable → Water temperature (°C)

Time (s)	Water temperature (°C)
0	15
10	16
20	18
30	22
40	28
50	32
60	37

When you learn more about graphing, you will also see that you need to know which is the independent variable and which is the dependent variable to construct a good, scientific graph.

Repeat trials and repetition

A well-designed investigation should be reliable. The reliability of the data can be increased by repeating the procedure. For example, if you wanted to investigate the time it takes for a ball to fall from a table you would do it more than once to make sure that the **trial** was not an error. You would do the test at least three times and then look at the results. If they are consistent then your results are probably reliable. If the results are different you should continue with the trials until the results are consistent. Or, you could evaluate the design of the experiment.

In some investigations it is not possible to repeat the test because it is **destructive testing**. For example, the time it takes a seed to germinate cannot be done with the same seed more than once. In this case the experiment is replicated. For example, ten seeds could be grown in three dishes with each seed acting as a repeat trial.

Before you go on, make sure that you know the meanings of the following terms.

Experimental design vocabulary

Define the following terms:

hypothesis

control

controlled variable

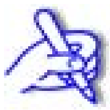
independent variable

dependent variable

Check your answers.

Experimental design practice

The concept of a fair test is a difficult one so some practice at this point is a good idea. If you are confident that you can design a scientific test then continue with your research project.



Have a go!

Answer the questions for the following experiment.

Ten cans were filled with equal amounts of water. Five of the cans were painted with black paint and five were painted with white paint. The temperature of the water was measured for all the cans before they were placed in bright sunlight. The temperature was then recorded every minute for ten minutes. The raw data recorded by the student is on the next page.

1 What is the independent variable?

2 What is the dependent variable?

3 What variables are held constant?

4 Write a hypothesis for this experiment.

5 Put the results as presented data in a table. Include a title for these results.

Black painted tin: 15, 16, 17, 19, 20, 22, 23, 24, 24, 24, 24

White painted tin: 15, 15, 16, 17, 17, 18, 18, 18, 19, 19, 20

Check your answers.

Your plans

Answer the questions below in your logbook for the investigation you are planning. If your investigation contains several experiments, answer the questions for one experiment only. (However, you need to check that you can answer these questions for all the experiments you plan.)

1 What are some variables that you will (try to) control in your experiment?

2 Do you have an independent variable? What is it?

3 How will you change your independent variable during the experiment?

4 What do you expect will be affected by changes in your independent variable? (This is your dependent variable.)

5 Predict how your dependent variable will change during your experiment.

The concept map in your logbook contains some questions that you have considered in your planning so far. Make notes under the relevant questions to summarise what you intend to do.

By the end of this lesson, you should be able to show, using your logbook, that you have completed all the planning and preparation and are ready to begin collecting data for your project.

Use the check list to check your investigation. Do not begin the investigation without speaking to your teacher.

☐ Does the title have the dependent and independent variable in it?

☐ Does the hypothesis show how changing the independent variable affects the dependent variable?

☐ Is the independent variable clearly stated and does is cause the change in the dependent variable?

☐ Is the dependent variable clearly stated and is it affected by the changes in the independent variable?

☐ Are the all other variables kept constant?

☐ Is there a control? Is one necessary for the investigation chosen.

Complete Exercise: Experimental design practice.

By this stage make sure that are now doing your research.

Suggested answers

Experimental design vocabulary

hypothesis

a statement of the possible relationship between the independent and dependent variable

control

part of the experiment that is used as a standard

controlled variable

a factor that is not allowed to change during the experiment

independent variable

the factor that is changed during the experiment

dependent variable

the responding factor; the factor that changes in response to changing the independent variable

Experimental design practice

1 What is the independent variable?

Colour of can

2 What is the dependent variable?

Temperature of water

3 What variables are held constant?

Cans, amount of water, amount of time in sunlight.

4 Write a hypothesis for this experiment.

The black can will heat up faster than the white can.

5 Put the results in a table

Heating water over time in different coloured cans.

Time (min)	Temperature °C	
	Black can	**White can**
0	15	15
1	16	15
2	17	16
3	19	17
4	20	17
5	22	18
6	23	18
7	24	18
8	24	19
9	24	19
10	24	20

Exercises – Collecting data and fair testing

Name ____________________

Teacher ____________________

Exercise: Finding information

1 Briefly describe the kinds of information that you have been looking for in books, on the Internet and/or in other sources.

____

____

____

____

2 Why are you looking for this information? (Explain why this information will help with your project.)

____

____

____

3 What other information do you need and how will you obtain it?

____

____

____

____

Exercise: Making a reference list

1 Give three reasons why it is important to keep a record of the source of any information you use.

2 You have found a book in the library and need to reference it correctly. What information will you need to do this?

Exercise: Making observations

1 Place the following descriptions into the table below.

The temperature was 37°C

The temperature felt the same as my body temperature.

The leaf was 12 cm long.

The leaf was green.

The mass of the block was 62 g

The block was shiny.

Quantitative	**Qualitative**

Now make up a qualitative and a quantitative statement yourself and put into the table.

2 A student counted the number of birds visiting a dam. He used tally marks. Here is the information he wrote into his logbook

7 am ~~////~~ ~~////~~ ~~////~~ /

8 am ~~////~~ ~~////~~ ////

9 am ~~////~~ ////

10 am ~~////~~ //

11 am ///

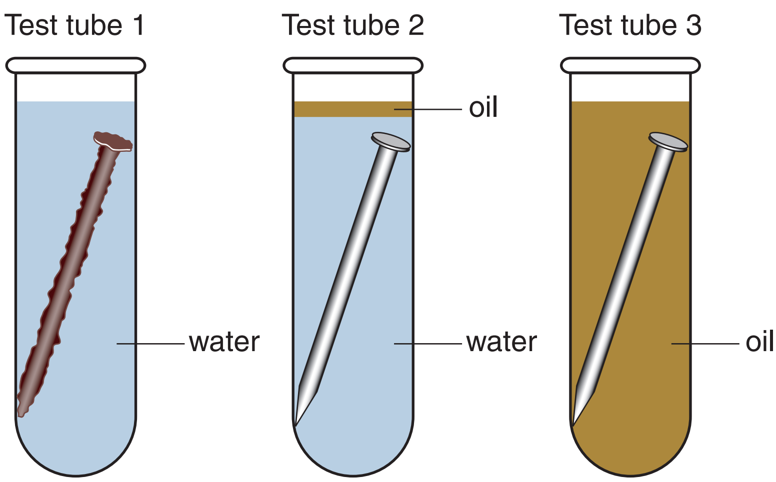
12 pm

Total the tally marks and then construct a table to show this information.

Exercise: Experimental design practice

Read the following features of an experiment designed to test the effects of air on rusting and then answer the questions.

- Three identical iron nails were placed in three test tubes.
- Test tube 1 contained boiled water (boiling the water removes some of the air)
- Test tube 2 had boiled water and a layer of oil.
- Test tube 3 had oil only.
- The liquid in all three test tubes was equal. After a week the result were recorded.



Results of experiment

Test tube number	Condition of nail
1	very rusted
2	not rusted
3	not rusted

1 What is the independent variable in this experiment?

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2 What is the dependent variable?

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3 What variables are held constant?

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4 What is the control?

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5 Write a hypothesis for this experiment.

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