Introduction

Scientists customarily process the findings they have collected and the conclusions they draw into various kinds of visuals in order to represent the data. Focusing on the subject of visuals, with its extensive content and diverse forms of representation, can help students to understand written scientific content and particularly texts that require complex, deep and abstract thinking. Visual representations help students to link the pieces of information together, to arrange them in logical continuums, and to come up with a better understanding of meanings and implications.

Data representations are divided into two main types: tables and figures (see Figure 1.0). Both of these kinds of representations appear in scientific articles, but they are usually numbered separately – a number sequence for tables and a number sequence for figures.

In science, different types of information can be represented by visual representations.

Type of information	Method of visual representation
Classification	Table, diagram, tree
Structure	Illustration or diagram (including arrows, labels, notes)
Process	Stages diagram, flow chart, table of stages
Description of experiment, solution to problem	Table – divided into stages, problem and solution diagram, flow chart

This Skill Area looks at:

1 The interpretation of visual presentations which students may find confusing Post-16. For example, it includes different atomic models, chemical formulae and imaging techniques.

2 Interpreting, processing and constructing tables of data.

3 Interpreting graphs from the simple to complex.

Intended learning outcomes

Students will be able to:

- recognise the importance and use of a wide range of visual representations of data in science
- develop skills to organise and interpret data in tables and graphs.

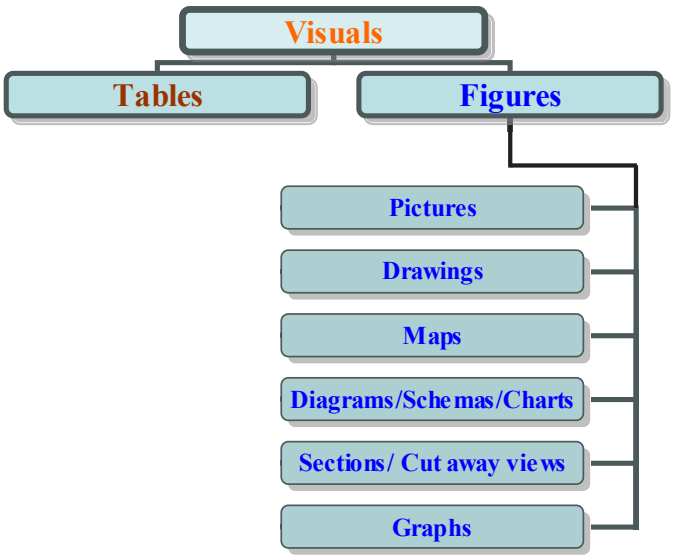


Figure 1.0

Types of visuals

Relates to Activity 4.2 Types of visuals.

If information is divided between different visuals or between visuals and text, the cognitive load imposed as students combine information from different sources can have a negative effect on learning. This is called a split-level effect. Skill Area 4 activities help develop students' processing skills by helping them to recognise explicit links between different visual representations of the same thing.

Biology Activity 4.2 considers different imaging techniques for blood cells. Students analyse images and consider different types of imaging and the information they provide. This activity is also very useful at getting students to compare, contrast and evaluate different imaging techniques.

Chemistry Activity 4.2 explores the different ways that molecules can be visually represented and provides an opportunity for students to draw them. Learners are encouraged to consider the advantages and disadvantages of the different representations and when they might be used.

Physics Activity 4.2 considers different visual predictive scientific models, which are used frequently in Physics. Learners are encouraged to consider the strengths and limitations of the different models. This is a useful activity and should alleviate the confusion that can be created by the use of different models. Discussion and sharing of ideas should provide an opportunity for students to tackle misconceptions and support their understanding.

Tables

Relates to Activity 4.3 Learning from tables.

A table is a visual representation comprising cells arranged in columns and rows, which serves to organise data logically in a comparative manner.

The structure of the table, the number of columns and rows, and the manner in which they are laid out, depends on the patterns and trends it is designed to emphasise. A well-organised table makes it easier to analyse and understand results and draw correct conclusions. The principal advantage of arranging data in a table is that it can be used to draw conclusions and make calculations from the data presented: data can be arranged in an ascending or descending order, numerically or alphabetically, or in groups. The table can be used to calculate differences and averages, for example.

Students frequently experience difficulties with reading and constructing tables.

There are five issues on which to focus.

1 Students are not well versed in reading tables that include a number of parameters, measurements of certain types, or categories for comparison.

2 Students find it difficult to identify the parameters under review and to define them accurately. Hence, they also encounter difficulties when it comes to defining the units of measurement.

3 Students find it difficult to deduce knowledge from the data and information presented in the table – to translate the data in the table into a verbal description and analyse the data presented.

4 Students find it difficult to draw links between verbal questions and the answers 'hidden' in the table of data. The difficulty exists in both directions – from the question to the data, or from the data to the question.

5 Students find it difficult to construct a meaningful table from raw data.

Activity 4.3 gets students to engage with the contents of a table of data and use it to make further calculations. Students should be provided with an opportunity at the end of the lesson to discuss what they found difficult with using the table and strategies that they used to help access the information. They should also consider how the design of the table supports its purpose.

Processing large data sets

Relates to Activity 4.4 Processing large data sets.

Students learn and practise all the stages involved in transforming a description of a study into a suitable table. They have to make decisions regarding the structure of the table, including the number of columns and rows, the headings for the columns and rows, and a title.

The standard format for processing data in a spreadsheet is to arrange the table as follows:

- columns present the parameters with which one is dealing, with each parameter assigned to a separate column
- rows present the categories for comparison; for example, time categories (minutes, hours, days, weeks, months, years), different population groups (marital status, age, certain characteristics, and so on).

The transition from a crude list of figures or pieces of information to an organised table is a difficult one, which requires experience and sophisticated thinking skills (analysis and synthesis). This difficulty should be dealt with systematically, and students should be trained in reading and setting up tables of various types, with increasing levels of complexity.

Using data to tell stories

Relates to Activity 4.5 Using data to tell stories.

This is a challenging task but should prepare students for research tasks they may need to complete in the future. Students will need to have had experience working with complex data sets before tackling this activity. They could work initially in groups formulating questions to explore and inferences from data.

Strategies to support skill development

Guide the students through these activities; model how you would do it.

Provide opportunities for the students to work on a wide range of tables with varying content, following the subject matter studied in class.

Questions related to particular data in the table should be incorporated in the activities to ensure that students know how to read a value in a table cell and understand its significance in relation to the other values.

These activities should be practised with the students a number of times, and incorporated into lessons on other topics to emphasise the transferable skills.

Graphs

Relates to Activities 4.5 Using data to tell stories 4.6 Interpreting graphs 4.7 Matching graphs and 4.8 Processing and representing data.

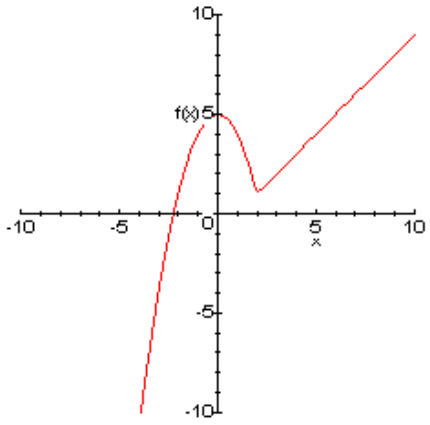
Graphs

A graph is an effective way of describing processes visually in order to demonstrate a connection between sets of data or to compare them. It draws attention to data and trends that are difficult to discern when the figures are presented in the body of the text, or in a table packed with data. The language of graphs has its rules, grammar and semantics, which requires study and practice. Users who do not know the language of graphs are liable to draw wrong conclusions from them.

What do students need to know?

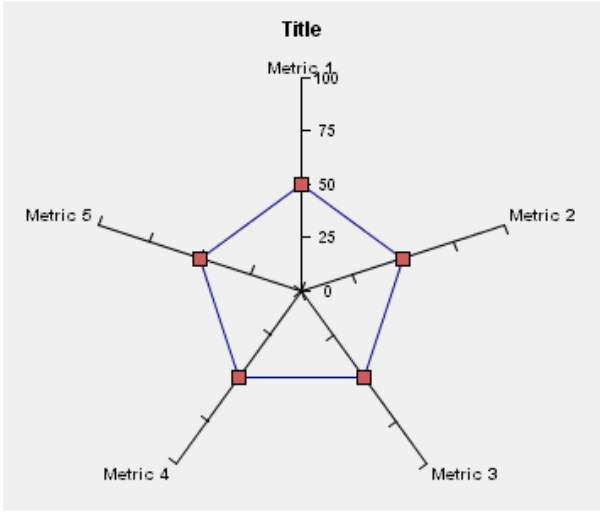
Graphs are used by many professionals in a range of fields including mathematics, physics, chemistry, economics, social sciences, technology, life sciences, medicine and more. In each field, particular kinds of graphs are chosen to serve the needs and research methods of that field.

For example, a line graph is used to display the behaviour of a function, as in graph no.1:



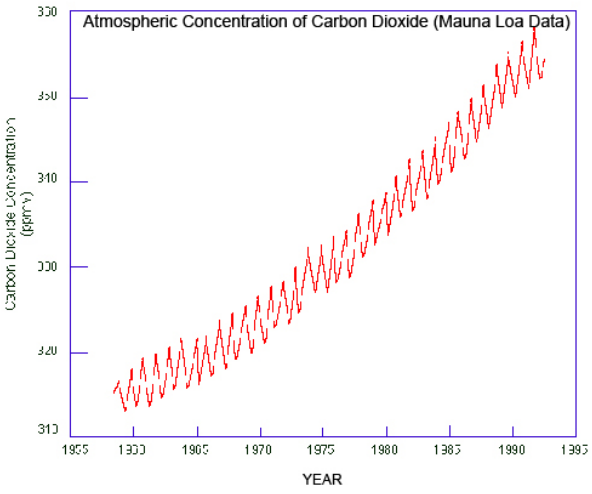
Graph no. 1: behaviour of a mathematical function

In the army, a radar graph is used to describe an object in space, as in graph no.2:



Graph no.2: radar graph to describe an object in space

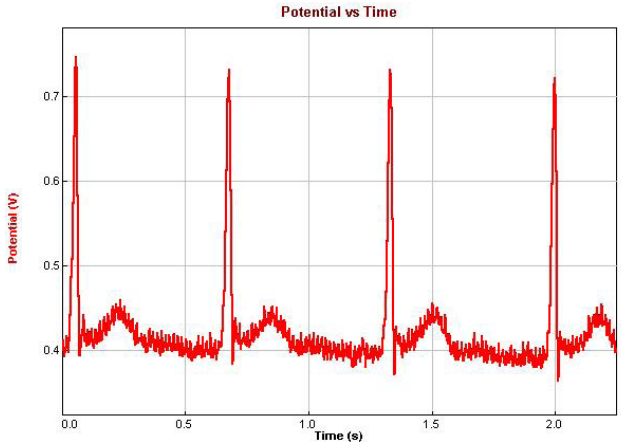
In Physics and Chemistry, a line graph is used to display the behaviour of various phenomena, as in graph no. 3:



Graph no. 3: concentration of CO_2 in the atmosphere

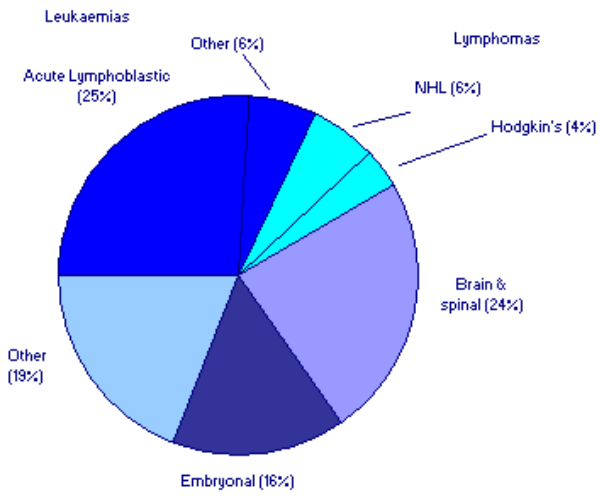
Graphs

And in medicine, a graph is used, for example, to display the results of a test using a measuring device over a period of time, as in graph no. 4:



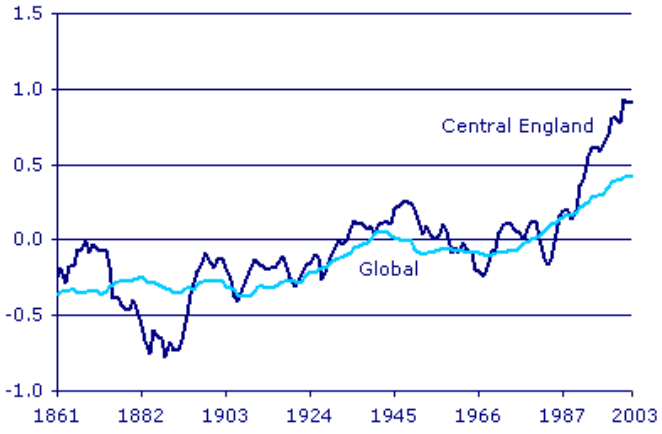
Graph no. 4: output from ECG exam

In these and other fields, pie charts are commonly used, as in graph no. 5:



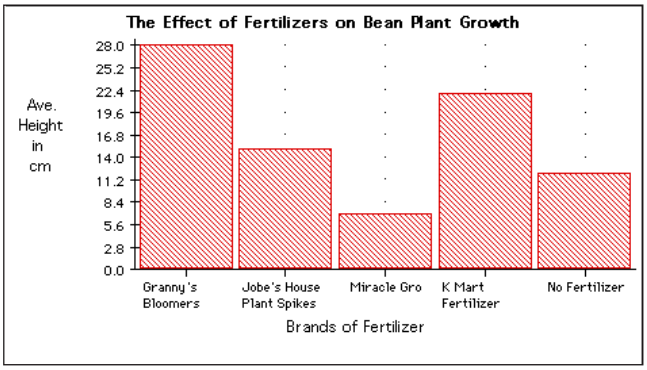
Graph no. 5: percentage of children surviving cancers

In environmental sciences a line graph is used to examine environmental changes over a period of years, as in graph no. 6:



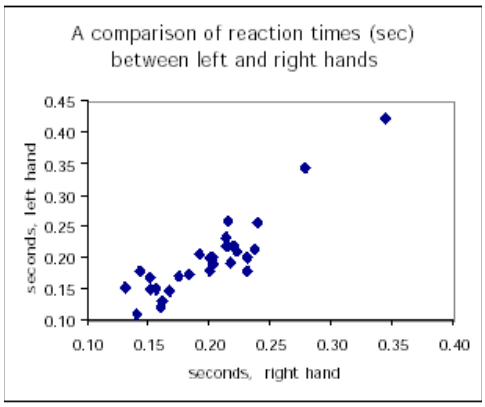
Graph no. 6: changes in average surface temperature in England

And in life sciences, a bar graph is used to display, for example, differences between populations, as in graph no. 7, or a scatter graph is used to show the connection between two factors, as in graph no. 8 on the next page:



Graph no. 7: the effect of fertilisers on the growth of bean plants

Graphs



Graph no. 8: examines the relationship between the reactions of right and left hands

Further examples of graphs can be found in the picture gallery of the Visual Mining site, which deals with economics and trade:

http://www.visualmining.com/developers/graphing-examples.shtml

Information about variables

In order to succeed in matching the graph to the question and the nature of the data you want to represent in a graph, it is important to become familiar with the concept of the variable, and to learn to distinguish between quantitative and qualitative variables and between continuous and discrete quantitative variables. This is usually taught in mathematics lessons, as is the creation of graphs describing the behaviour of different functions. It is important to check whether students are familiar with these terms and know how to use them.

Brief glossary of terms

Qualitative variable – a variable representing a property, behaviour or state that cannot be quantified. Its values can be described in words or numbers.

Words - to describe, for example: the variable of eye colour, where the values would be blue, black, brown or green.

Ordinal – to represent a certain succession (these numbers do not represent quantities). For example, a series of grades in a competition.

Quantitative variable – a variable where the values are numbers which represent a quantity and are measurable, for example, the height of a person. A quantitative variable can be discrete or continuous.

Discrete quantitative variable – a variable where each value stands alone, and it is not possible to add intermediate values of any quantitative significance between one value and the next, for example, the number of children in a family.

Continuous quantitative variable – a variable whose values form a continuum, where an additional value of quantitative significance can be inserted between two values, for example, the variation in temperature in a den in the course of a day.

Assuming that the students know how to use a spreadsheet to produce a graph, it is important to guide them in the choice of the appropriate graph from the vast range available in the program.

It is easy to choose the appropriate graph if you know how many variables are to be displayed and what type they are.

The following table can help in choosing the right type of graph. It allows you to match the number of variables and their type with the most suitable graph.

Type of variable		One variable	Two variables
Qualitative		Bar graph, pie chart	Bar graph
Quantitative	Discrete	Column graph, pie chart	Bar graph
	Contin-uous	Line graph, histogram	Line graph, histogram, scatter graph
	Discrete plus contin-uous		Bar graph etc