'Graphicacy': the fourth 'R'?

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Introduction

Graphicacy is the ability to understand and present information in the form of sketches, photographs, diagrams, maps, plans, charts, graphs and other non-textual, two-dimensional formats. The information conveyed can be directly representative of what we see (as in photographs or drawings) or more abstract - for example information which is spatial (as in maps, plans and diagrams) or numerical (as in tables and graphs). A certain level of graphicacy is assumed of the adult population nowadays, as demonstrated by the widespread use of graphics in newspapers, television programmes, instruction manuals and government information leaflets aimed at the general public.

Graphics offer three major advantages in comparison to text. Firstly, they are concise: a photograph can set a scene immediately (e.g. the Empire State building towering above the Manhattan skyline). Secondly, they are memorable: when Londoners are asked what line Oxford Circus is on, they generally visualise the tube map. Thirdly, they make relationships within the information readily apparent: not only spatial relationships (as with a map showing major cities in a country, or a diagram showing how to assemble a piece of equipment) but also non-spatial relationships (as in a table showing population figures or a line graph showing rise and fall in share values).

A child's first encounter with a range of graphics (other than storybook pictures) is likely to be at primary school. Primary level books have a higher ratio of graphics to text than most adults' books because they aim to attract beginning readers to the page. Science books in particular make use of a wide variety of graphics to communicate about structures, processes, procedures and measurements encountered in learning about living things, and about light, sound, chemical reactions and so on.

Unlike literacy, graphicacy is rarely taught explicitly, despite being an important skill as we have argued above. Although the National Curriculum for primary science at key stage 1 (5-7 year-olds) states that children falling within this category should be able to: 'Present scientific information in a number of ways, through drawings, diagrams, tables and charts, and in speech and writing', on the whole its agenda regarding graphicacy is an implicit one. Children seem to be expected to 'pick it up as they go along'. In this context children's misunderstandings or difficulties may not come to light. In fact, some adults never get to grips with information presented in a graphic form. So it is particularly important that textbooks should offer children good, clear examples of graphics from which to learn. As we show below, too often this is not the case.

Primary science teaching provides a unique opportunity to address the issue of graphicacy explicitly, and to lay good foundations for this life-long skill early on. We hope that our arguments will persuade you that this is worth doing, and that the suggestions we make will help you get started without too much effort.

Graphics in primary textbooks

We recently carried out a survey of primary science textbooks, analysing the use of graphics in thirty-four books published between 1981 and 1998. The books generally had a high ratio of graphics to text as one would expect of books aimed at this age group. The design of the graphics was very variable in quality, however, even within the same book. By giving you an overview of our findings we hope you will begin to look at graphics with a more critical eye. A few graphics in our sample were downright misleading. Often the reason behind this seemed to be considerations about page layout. For example, in a line drawing of a row of houses showing supply of water and electricity, the artist had extended the pipes and cables to create a border around the picture. Unfortunately this meant the water and electricity ran in circles round the houses, apparently miraculously replenished - no suggestion of where the supplies came from. Watch out for artistic licence going too far!

A substantial proportion of the graphics in our sample added nothing to the text in terms of content. Often these took the form of photographs, pictures or line drawings of a real life scene or objects. Their principle purpose appeared to be 'sugaring the pill' of the text. This is arguably a worthwhile function where beginning readers are concerned. Where such graphics are immediately recognisable to children they can be useful in establishing context and provoking interest, such as a photograph of a windmill on a page about the weather. It is worth while being aware of how little some graphics convey, however, so that you do not find them taking up too much class time.

Many of the graphics in our sample were potentially confusing because of their dependence on prior knowledge. Often it was not until we had pulled apart an example in our discussions that we realised just how much you needed to know beforehand to be able to understand it! Obviously this may cause difficulties for primary school children who are only just beginning to encounter a variety of graphic formats and conventions. In the next section we look in detail at the sorts of prior knowledge often assumed - a quick comment is often all that is needed to prevent misunderstandings arising in the classroom.

Prior knowledge needed to understand graphics

Through our survey we identified three categories of prior knowledge which graphics in primary science textbooks often rely on without explanation:

Views. By this we mean different perspectives on objects or parts of objects, including a magnified view, a distant view, cross-sections, changes to scale and 2D depictions of 3D objects. Examples include a diagram of the eye in cross-section, a photograph of a leaf's surface at high magnification and a 2D drawing of the DNA double helix. It is obviously important to establish that children understand the nature of the view being presented to them. This can easily be overlooked especially where the nature of the view is very familiar to adults. It is interesting to note that story books even for very young children expect them to understand cross-sections. For example a rabbit family may be shown inside their burrow - a view only possible by 'slicing' down through the ground, as illustrated in figure 1.

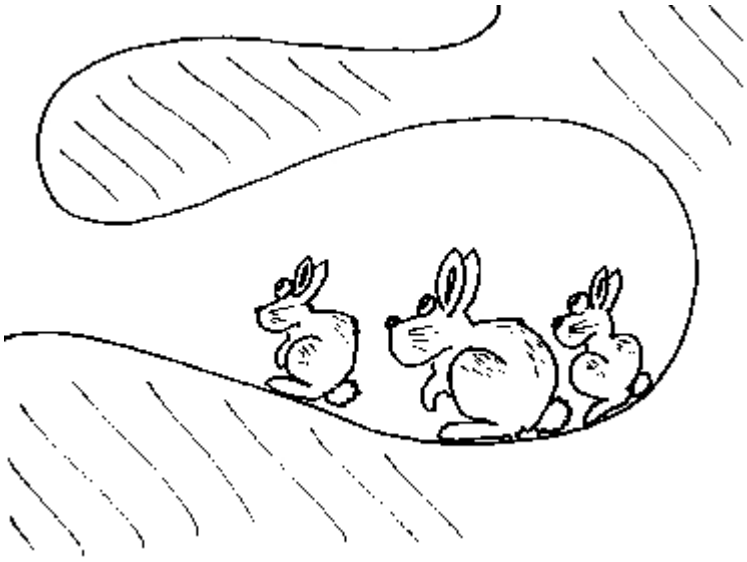

Figure 1. Views: *Cross-sections are often deceptively familiar to adults but may need to be explained to children.*

Formats. By this we mean the various different types of graphics and their associated sets of conventions. Pictures and photographs are readily interpreted even by very young children but the meaning of maps, pie charts, bar charts, line graphs, circuit diagrams and so on is not readily apparent to a first time viewer. Different conventions about symbols, keys, axes, x/y co-ordinates and so on must be learnt before these graphics can be understood. Any gaps in the understanding of such conventions create potential for confusion and misinterpretation of the information presented. Even as adults we may encounter unfamiliar graphic formats which require explanation before we can interpret the information displayed. Figure 2 shows an example.

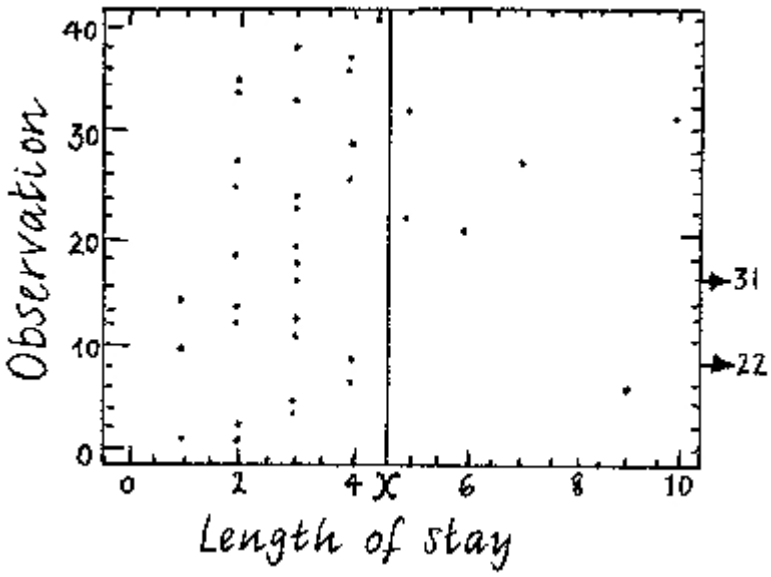

Figure 2. Formats: *A dot plot showing length of hotel stay. To most of us it's baffling until the conventions of the unfamiliar graph are explained.*

Commentary. This refers to commentary objects, which often take the form of lines or arrows. These objects are not supposed to be interpreted literally, as part of a visual scene, but symbolically, as a 'commentary' on that scene. Figure 3 shows some examples of lines used in this way. Other examples would be a diagram of a prism with lines showing how light refracts, a family tree with arrows showing descendants, or a picture of pond creatures with arrows showing the flow of energy through the food chain. It is frequently assumed

that the meaning of commentary objects like these is understood and needs no explanation. To complicate matters their meaning varies according to context. For example, lines can be used to indicate movement, or to depict sound or light (again see figure 3). Arrows can be used for labelling, to show movement, and to indicate direction, sequence and choice points (as in a flow chart). Misunderstandings about commentary objects arise in two ways, when children interpret them as real objects within a scene, and also when they jump to conclusions about meaning, having encountered something similar in a different context.

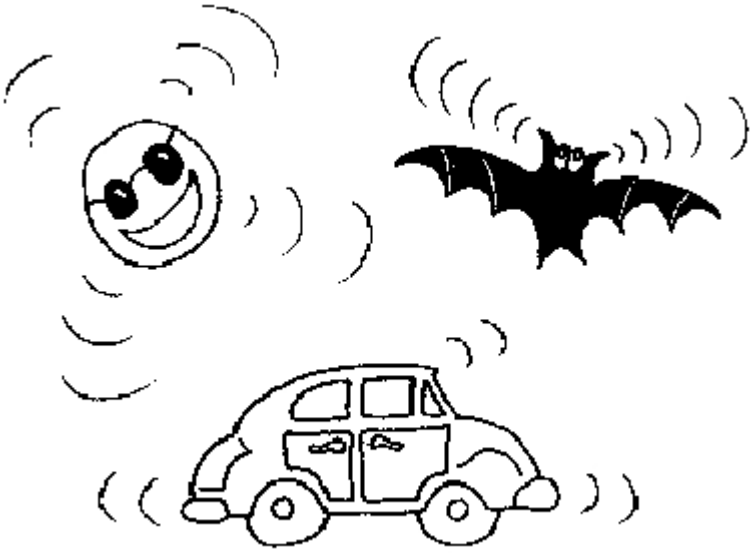

Figure 3. Commentary Objects: *The same lines may be used to represent heat, sound and motion. Particularly as these are not real-world objects there is a lot of scope for misunderstanding.*

Putting graphicacy on the agenda

If we have convinced you by this stage that graphicacy is important and may not be picked up satisfactorily by children as they go along, you may be wondering how much effort it would take to put it on the agenda explicitly. Not a great deal, we would argue, especially in relation to the possible gains. Here's one way to go about it but we would be interested to hear about others.

1. Draw up a 'hit list' of graphic formats with which you would like your class to become familiar. The list will depend on the age of the children you are teaching of course, but aim to include contrasting types. For a young group the list might be: picture, map, labelled diagram. For an older group it might be: table of figures, pie chart, bar chart, diagram, flow chart.

2. Be critical in your choice of examples.Look for opportunities to present graphics within the context of the topic you are teaching but make sure they are relevant, clear and informative. If you are not happy with a graphic, substitute another from a different source or draw something yourself. It may be quicker to produce one yourself than to search through different books; 'the simpler, the better' is often the case with graphics. Trust your judgement as a teacher that you can produce a better graphic than the one of which you are critical.

3. Present two or more examples of each graphic format in different contexts. Showing the children the same format in the context of different topics will help them understand the nature of that format and how it might be applied to other topics.

4. Prompt children to think about the relative merits of different formats. Here are some suggested questions to get discussion going. What is this graphic trying to get across? Does spatial layout matter in this format? Does this particular example do its job well? Could this particular example be improved? (e.g. through simplification, colour, key, scale, a more informative title, etc.) What alternative formats could be used to display this information and how would this affect the viewer? (e.g. exact values are easier to read from a table; trends are more apparent from a bar chart).

5. Get children to produce their own graphics using your target formats. Even simply copying a graphic can be a worthwhile exercise as it helps children learn the component parts and what aspects are important (for example, exact spatial layout is crucial in a map but not in a electric circuit diagram). Getting children to present new information within a known format obviously provides a greater test of understanding though, and can be invaluable in highlighting any misconceptions.

Adopting all or any of these suggestions should help your class towards graphicacy. Pick and mix between them, adding ideas of your own, and please let us know of any particularly successful strategies you come up with.

Keep 'CLEAR' in your mind

Finally, we've developed a simple way of remembering the criteria to apply when selecting a graphic and assessing its usefulness as a teaching aid. This takes the form of a mnemonic:

C is for central point.
What is the purpose of the graphic? Is it just to make the page more attractive or does it give information not in the text?

L is for layout.
Is the graphic well-designed and clearly presented? Does it do its job well?

E is for example.
Is the graphic a good example of its type? Can it be used to teach about graphics more generally?

A is for assumptions.
What prior knowledge is assumed of the viewer? What misconceptions might arise if these assumptions are not met?

R is for redesign.
If you are critical of the graphic, consider redesigning it yourself.

Conclusion

If the idea of adding graphicacy to your list of teaching objectives makes you sag at the knees, don't worry! The key to improving graphicacy in the classroom lies principally in your own awareness of the different forms and functions of graphics. The pointers we give here provide a starting point but once you have developed a critical eye you will find that you appraise graphics almost automatically. If you select good examples and explain potentially misleading features you will most certainly help children pick up graphicacy 'as they go along'. If, in addition, you prompt children to think about the pro's and con's of different graphic formats, you will equip them with a communication skill that will be useful throughout their lives.

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Frances Aldrich and Linda Sheppard are research psychologists at the University of Sussex. Frances's research specialism is the design of learning materials, especially the way that design affects memory for the material. Linda specialises in the study of memory, particularly how actions during learning affect subsequent recall.

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