

Science teaching and literacy, part 2: Reading

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The second of three articles on bringing the key stage 3 literacy strategy into science teaching.

This is the second of three articles aimed at helping science teachers to tackle the new national literacy strategy at key stage 3 (11–14 year-olds) in English schools (DfEE, 2001). The first article (Staples and Heselden, 2001) addressed **writing**, and the third will cover **speaking and listening** and **spelling and vocabulary**. As well as exploring the rationale behind the literacy strategy, our initial article emphasised the need for science teachers to incorporate the teaching of literacy within their lessons; we made the point that science has a literacy of its own which is separate from the core literacy shared by all subjects, and science teachers have a responsibility to develop literacy in their pupils. This enables pupils both to access the science curriculum and to explore standard methods of communication within the subject. We continue to pursue this theme here.

As previously stated (Staples and Heselden, 2001), the intention of all three articles is to provide support for departments or individual teachers by:

presenting the subject of literacy with only as much technical language as is necessary, and explaining any technical terms where their use is unavoidable;

ABSTRACT

The new national strategy for literacy at key stage 3 in English schools is important for science teaching and learning. The first article in this series dealt with writing. This article discusses the importance of reading in science lessons, and it offers practical solutions to the problems of structuring shared reading, making reading active, encouraging note-taking, and locating potential sources of reading material. The third article in the series will deal with spelling, vocabulary, and speaking and listening.

- suggesting possible contexts in which various aspects of the literacy strategy can be taught;
- offering clear and helpful guidelines on potential teaching approaches.

In the present article we look in turn at why reading in science lessons is important, ways of structuring shared reading within lessons, how to turn reading in science from a passive to an active task, the process of taking notes from text, and potential sources of reading material for use in science lessons.

Why is reading in science lessons important?

It is rare for extended reading to be a part of science lessons. Lunzer and Gardner (1979) found that year 7 pupils (11/12 year-olds) spend only 9% of science lesson time reading, with this figure increasing only slightly to 10% by year 10 (14/15 year-olds). Up to three-quarters of this time was actually spent reading from the blackboard or from exercise books rather than from printed texts. Wellington and Osborne (2001) considered that these figures are still accurate today. Working scientists, by contrast, read journals alone for at least five hours a week (Bulman, 1985). Clearly, practical hands-on classroom activities should be balanced by reading and research if pupils are to get a real taste of what it is to be a scientist.

Wellington and Osborne (2001) make two key points regarding the importance of reading in science lessons:

- Reading is a scientific activity. To be capable of reading carefully, critically and with a healthy scepticism is a vital component of being a scientist.

- When the majority of pupils leave school they are far more likely to read about science than they ever are to do it – most of the public glean their information about science from the media.

We would add two more points about the importance of reading, even though they may sound obvious:

- If pupils are to achieve their potential in any subject, they need to be able to read and understand their notes, their textbooks and the exam questions. All that money invested in science textbooks is totally wasted if little time and attention is devoted to teaching pupils how to read what is a strange and unfamiliar text.
- If pupils are to operate successfully in the adult world, the ability to read is vital – whether it be to understand a report on an aspect of their job, to read a job advertisement or even just to find a plumber in the telephone directory.

Our last point was carefully chosen: a report on adult literacy in 1999 (DfEE, 1999) found that *'seven million adults in England cannot locate the page reference for plumbers in the Yellow Pages'*.

Our last two bullet points also highlight two key issues with regard to literacy and reading – **reading to learn** and **learning to read**. As stated in our previous article, schools relying solely on the English department to teach literacy skills are unlikely to be successful because pupils do not readily transfer these skills between subjects. Like any other skill, the ability to read about science critically and carefully will only be developed through coaching and practice. Science departments need to become involved in actively teaching pupils reading skills as well as using reading to help pupils learn. The strategies and techniques we suggest here will help pupils to do both.

Shared reading

Teacher as model

Teachers are able readers and as such it is easy for us to take our reading ability for granted and not fully understand the difficulties pupils might have. In our first article, we suggested that it was important for teachers to model various writing styles before asking pupils to put pen to paper. The same is true of reading.

In science lessons, pupils are often asked to read extracts from textbooks. When starting a new topic, rather than telling the pupils to turn to a certain page and just start work the teacher can develop reading

skills by being a 'model' reader – this means talking about the process of reading and finding information. By no means are we suggesting that you do this every time you need to use a textbook, but if you never do it some pupils will fail to become independent readers. As a result, if pupils are asked to research a science topic for homework they may have difficulty even locating relevant chapter titles, let alone finding useful information. The following process can be useful:

- Ask pupils to find the relevant chapter in the textbook. When you do this without modelling the process, you are likely to find that many pupils start flicking randomly through the book. As a 'model' reader you can talk through the process of using the contents and/or index pages (bearing in mind that the least able readers may not even know their alphabet let alone that an index is in alphabetical order). If it helps, you could use the analogy of finding information on the Internet. First, it is necessary to choose a search engine (this is akin to the contents or index page), and then you have to enter key words so that the search engine can scan the Web (essentially the same as a pupil scanning the index or contents pages of a textbook to find a desired word).
- Once you have found the page, talk about how you can tell the difference between the chapter heading and the subheadings. You are likely to cover aspects of the text such as page layout and font sizes.
- If you want pupils to be able to locate a particular section of the text, talk about how you would find that information by using subheadings and/or scanning the text for key words.
- If you require pupils to 'read' an illustration or diagram, explain how this is done – where do you start? How do you make sense of the information presented?
- As you read a text and come across a word that you know students are not likely to understand, you can model how you find out the meaning. This can involve reading ahead to see if the meaning becomes clear later in the text, working it out from the context, using previous knowledge about word roots (e.g. exothermic from Greek *exō* [outside] and *therme* [heat], i.e. 'giving out heat'), and/or using a glossary or dictionary.

All of this may seem laborious, but it is really worth setting aside a little time to try it. This small invest-

ment can pay dividends! The teacher as 'model' reader is expanded on in later sections of this article.

Reading aloud

If science teachers are to act as model readers, then it goes without saying that they will have to read aloud some of the time. However, if the teacher *always* does the reading aloud then lessons will soon become tedious for teacher and pupils alike. On the other hand, one pupil who likes reading aloud but does not do it particularly well can also kill a text. It is important to be aware of the range of reading abilities in a class: a more able reader can be frustrated if restricted by the reading and understanding abilities of other pupils in the class. Using a variety of techniques is important.

If you want to get a whole class reading a text, we would not advocate forcing a pupil to read aloud if they do not want to. They can, however, be gently encouraged if they know that they only have a little to read. With weaker readers, reading as little as a sentence each can work. Ideally they need to know what their sentence will be so they can read it in advance. You might go round the class and say pupils can read as little as a sentence or as much as a paragraph depending on what they feel comfortable with. When it is the turn of a weak reader, if the teacher or classroom assistant is next to them they can quietly prompt. It is important to bear in mind that pupils will be more confident about reading aloud if they feel safe in the environment: they do not fear others laughing if they stumble or being humiliated for hesitating. An additional point is that pupils are generally much better at listening to each other speaking than at listening to the teacher.

Reading, however, does not have to be a whole-class activity. If pupils of a range of ability are present, it can be equally or more successful if pupils read together in groups or pairs. This type of activity can be enhanced by asking a pupil who is listening to summarise the piece that has been read back to the reader. An additional way in which to give the activity a more formal structure is to get the reader to ask the listener two or three questions about what they have heard, and then swap roles – listener becoming reader and vice versa. With able readers, of course, reading in silence is also useful.

If you choose a route other than whole-class reading of a text, you can also differentiate the texts or tasks based on the text that you provide for pupils. The challenge of the science classroom can be that able readers are not necessarily the best scientists and

vice versa. Therefore, when the focus is on reading a text to extract information consideration needs to be given to groupings. The SEN and/or English department should be able to provide information about pupils' reading ability.

No matter how you choose to read the text, changing the reading from **passive** to **active** is vital.

Passive and active reading

It is all too easy to read an article or a passage from a book and then, having done so, realise that you have taken in very little of the meaning. This often happens when you are not fully concentrating on the words on the page, which for many pupils is most of the time. Simply asking pupils to read text will not necessarily provide them with an effective learning experience, and they should therefore be encouraged to somehow digest the meaning and then reformulate it in some way. Science teachers need to be aware of the difference between **passive reading** and **active reading** (Davies and Greene, 1984) – see Table 1 – and as far as possible encourage and develop the latter.

Table 1 Passive and active reading.

Type of reading	General characteristics
Passive reading	No clear targets or instructions Not clearly guided or directed by teacher Usually a solitary activity
Active reading	Involves a specific purpose or purposes Teacher sets specific targets, instructions and goals Often collaborative, as a shared activity in small groups

Passive reading is fostered when teachers set tasks such as 'read this chapter for revision' or 'make notes from this section'. Davies and Greene (1984) point out that this is analogous to giving pupils a general instruction to do an experiment without any indication of the particular purpose of the experiment or how to go about it. In general, pupils need to be moved away from the idea that reading in science is no more than a rapid trawl for the right answer. Encouraging them

to indulge in more demanding, active reading tasks takes time but offers tremendous rewards for teacher and pupil alike.

DARTs

One of the most useful ways of encouraging active reading in science lessons is the use of DARTs (Directed Activities Related to Text). DARTs are one outcome of a major research project into reading for learning in secondary schools, carried out under the directorship of Eric Lunzer and Keith Gardner from 1978 until 1982. Florence Davies and Terry Greene were two project officers specifically studying science texts (Lunzer and Gardner, 1979; Davies and Greene, 1984). They set out to design activities (DARTs) that would focus pupils' attention on their reading and make them reflect on its content. DARTs had a major impact when they were first introduced, but a recent survey (Lewis and Wray, 1999) found that more than half of secondary teachers now use them 'rarely' or 'never'. It is therefore perhaps timely to review them here and make the case for their value and regular use.

There are many types of DART. They are designed to encourage pupils to read texts carefully and search for meaning, which means that they will have to understand and think about what they have read. Pupils generally enjoy them, providing they are presented with a variety of DART types over the course of a sequence of lessons, because they have a

game-like quality. Apart from being monotonous and repetitious, always using the same type of DART can quickly put a pupil off a subject, let alone off reading. From a teacher perspective, DARTs offer the dual benefits of effectiveness and ease of preparation. Furthermore, they can easily be differentiated through careful choice of text or task. Four classes of DART are explored below, with examples of how they might be used in key stage 3 science lessons.

Cloze activities

'Cloze' activities are one type of DART still widely used in both primary and secondary schools, and are perhaps more familiar under the name 'filling in the blanks'. Pupils are presented with a portion of text in which words have been blanked out, and working individually or in pairs they are asked to reconstruct the text by predicting the missing words. Possible ways of constructing a Cloze passage for class use include:

- omitting all the words directly related to the topic being taught;
- omitting words directly related to the topic but providing 'clues' – leaving the first letter of each word in place, *or* listing all the missing words at the bottom of the page;
- Leaving out words at fixed intervals throughout the text, for example every tenth word.

A note of caution, however, is necessary for Cloze activities. They need to be carefully composed to

Box 1 Example of a Cloze DART

Electrical charges

What you have to do:

Read the text carefully and then go back and fill in the missing words.

To help you, the missing words are listed at the bottom of the page.

All substances contain _____ charges. There are two kinds, _____ (+) and _____ (-). These _____ are normally present in equal numbers, and so cancel each other out. But if you rub two different _____ together you can knock some charges from one to the other and upset the balance. If you rub a _____ rod with a cloth, it becomes negatively charged. If you rub an acetate rod with a cloth, it becomes _____ charged.

Charges that are the same _____ each other. Charges that are different _____ each other. If enough charges of the same type can get together, they will have enough energy to jump a small gap as a _____.

Positive repel charges spark positively electrical polythene negative attract materials

ensure that reading has to take place. In the second example above, if every missing word begins with a different letter *and* the missing words are located at the bottom of the page, no text needs to be read and understood to get the right word into the right place. Some modern key stage 3 science texts abuse the Cloze concept by filling their pages with minimalist and ill thought-out examples such as these.

Teachers who want to be more inventive might care to invent a context for the exercise. Perhaps the words have been erased accidentally by a chemical spill in the laboratory? Parkinson (1994: 145) gives an example of a Cloze passage in which '*something has gone wrong with my computer and it has written in funny faces instead of letters*'. Cloze activities also work well as an ICT-based activity.

The added benefit of Cloze activities is that they can focus pupils on learning subject-specific vocabulary. An example is given in Box 1.

Sequencing

Sequencing involves the teacher dividing a piece of text into a number of discrete segments. Somewhere between six and twelve segments is ideal; below this

number and there is little challenge involved, above it and pupils may become frustrated! The segments are then shuffled in some way, and pupils are asked to put them back into the correct order. It is very easy to produce a sequencing DART using a word-processing package on a computer, and present it to every pupil as a photocopied 'cut-and-paste' activity akin to that in Box 2. This can have drawbacks, however. One is that pupils can spend excessive time carefully cutting out all the boxes, before simply glancing at someone else's completed order and copying it. In this case, the whole point of the exercise – getting pupils to read and think about what they have read – will have been lost. Another drawback can be if you ask pupils to sequence the segments and they then spend excessive time sticking each segment into their exercise books. With a little forethought, the same activity can be presented as a series of reusable laminated cards, with students asked to work in pairs or groups of three to discuss the correct order. Have a single pre-printed sheet with the segments correctly sequenced for their exercise books, so the focus is on the science not the glue. Alternatively, if you have sufficient computer access,

Box 2 Example of a sequencing DART

Chromatography

What you have to do:

Cut out these sentences. Decide in your group which order they should go in. Then stick them into your books.

Draw a pencil cross in the middle of your pencil line.

Allow the water to rise slowly upwards through the paper.

Suspend the chromatography paper in the glass beaker, making sure that the water is touching the paper but is below the level of the pencil line and ink spot.

Collect a rectangle of chromatography paper.

Using a piece of capillary tubing, put one drop of black ink on to the pencil cross.

Put 1 cm depth of clean water into a glass beaker.

On your paper, draw a straight pencil line parallel to the bottom edge of the paper and 2 cm above it.

Remove the paper from the water before the water soaks all the way up to the top.

Box 3 Example of a text marking DART**The blood**

Read through the following information, which is about the blood.

Adults have about 5.5 litres of blood. The blood's function is to transport substances around the body. About 55% of blood is a straw-coloured liquid called plasma. The remainder is made up of red and white cells (sometimes called corpuscles) and tiny particles called platelets.

Plasma is made up mainly of water, containing a variety of dissolved substances. Plasma transports dissolved nutrients from the intestine to all parts of the body, and carbon dioxide from all parts of the body to the lungs. It also carries waste substances from the liver to the kidneys, where they are excreted. Red and white blood cells, and platelets, are also carried round the body in the plasma.

There are about five million red blood cells in a cubic millimetre of blood. They are biconcave discs with no nucleus. They are made in the bone marrow and live for only four months before they are destroyed in the spleen and liver. Red blood cells owe their red colour to haemoglobin, a chemical that allows them to transport oxygen from the lungs to all parts of the body. White blood cells are completely colourless, and unlike red cells they have a nucleus. They can change their shape. There are only about 8000 white blood cells in a cubic millimetre of blood. Most white blood cells perform a very useful job in the blood – they destroy invading bacteria and dead cells. Platelets are tiny fragments of cells which are made in the bone marrow. They help your blood to clot when you are wounded.

What you have to do:

- Read back through the information, but this time underline in red the names of the different parts of the blood.
- Now go back and underline in green anything which describes what the different parts of the blood look like.
- Finally, underline in blue any information about what the different parts of the blood do.

the process can be done on the computer and the correct sequence printed off for pupils' notes.

Sequencing activities can be a particularly good way of getting pupils to sort out the correct order for the various stages of an experiment, especially if the activity is carried out immediately prior to the actual experiment (see Box 2). The other great advantage of this is that it forces pupils to think before they jump into the practical. This means that they have a more coherent sense of what they are doing and why they are doing it, and will generally complete the practical more efficiently.

Text marking

Text marking, or highlighting, involves asking pupils to locate and mark parts of a text that have a particular meaning. Pupils have to physically work their way through a text and highlight or underline words, phrases or sentences according to instructions given by the teacher. In order to do this they have to engage actively with the text and analyse it. This is a logical starting point to note-making on a particular topic. An example is given in Box 3.

Text restructuring

Text marking activities lead logically into text restructuring. This type of activity encourages pupils to read information and then present it in some other way. Pupils will have to work at understanding the text in order to do this. There are many different ways of restructuring text (see for instance Lewis and Wray, 2000: 42–46). These include:

- Rewriting the text in a different style (for example as a newspaper article).
- Turning the text into a table.
- Converting text into a time line.
- Drawing annotated visual representations of what has been learnt.
- Searching for information in a text and then using this to label a diagram (see Box 4).
- Restructuring relevant text as a flow diagram.

In an age when pupils have ready access to the Internet, restructuring is a useful activity to link to a research task. If pupils are to research a topic but you

Box 4 Example of a labelling DART

The digestive system

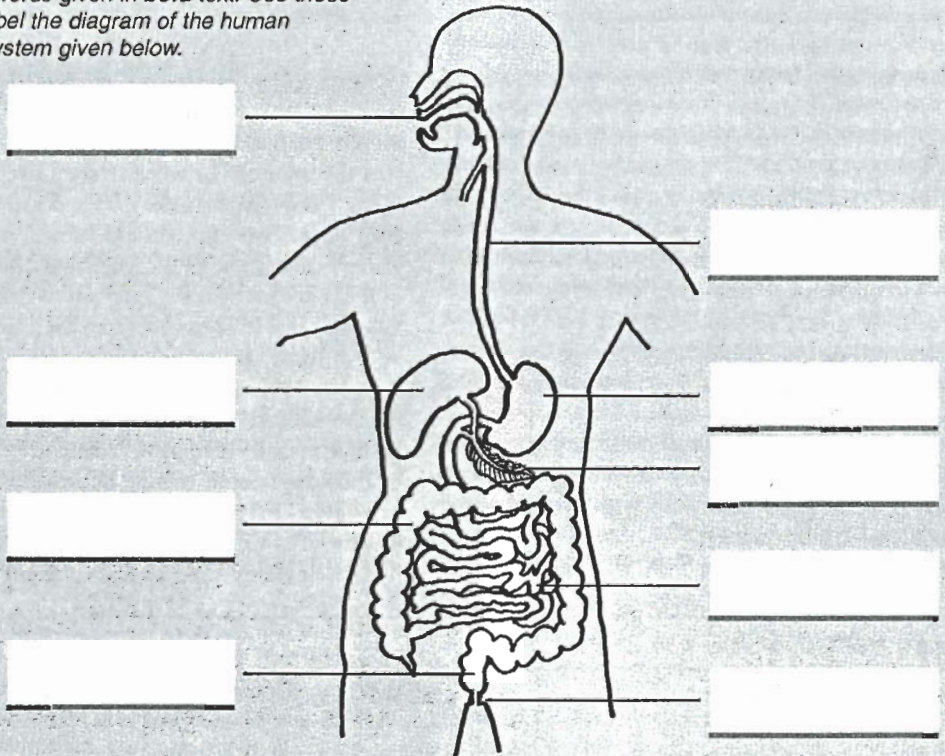
Read through the following information, which is about the digestive system.

Digestion starts in the **mouth** when your teeth crush and chew food, and **saliva** is added. The saliva contains an enzyme called **amylase** which starts to break down large molecules of starch and also helps to moisten the food. The food is then swallowed and goes down the **oesophagus** (gullet) to the **stomach**. It stays here for about three or four hours. Muscles in the stomach wall contract rhythmically, mixing food with a liquid called gastric juice. This contains dilute hydrochloric acid which kills bacteria. The acid also creates pH conditions which allow another enzyme, pepsin, to begin breaking down large protein molecules.

The partly digested food then passes into the **small intestine**, where bile from the **liver** and enzymes added by the **pancreas** continue the process of digestion. The starch is eventually broken down into glucose molecules, proteins into amino acids, and fats into fatty acids and glycerol. These molecules are small enough to be absorbed through the lining of the small intestine and into the bloodstream. Any undigested food and other waste products pass on into the **large intestine**, where water and salt are removed and solid faeces are formed. The faeces pass out of your body through the **rectum** and **anus**.

What you have to do:

The information you have just read included a number of words given in **bold text**. Use these words to label the diagram of the human digestive system given below.



wish to avoid having 30 print-outs from the Web to mark, asking pupils to complete the task and present the information in a particular format will force the pupils to read and process the information. Thus you

will know whether they have understood what they have read. You might ask for research on teeth, for example, to be presented as a leaflet to be handed out in a doctor's surgery. It is also good practice to ask

Box 5 Example of a summary DART

The Greenhouse Effect

What you have to do:

- Read through the following two paragraphs, which are about the Greenhouse Effect.
 - When you have understood what you have read, produce a flow diagram which summarises the processes involved in global warming.
- It may help you to underline sentences that you think are important.*

Historical temperature records have shown that the Earth is slowly warming up. This gradual increase in temperature has been called global warming, and is due to a process called the Greenhouse Effect. During the last hundred years the burning of fossil fuels and trees has led to an increase in the amount of carbon dioxide in the atmosphere. It is thought that this increase in carbon dioxide is what is causing the warming of the Earth, though other gases such as methane and nitrous oxide are also believed to be important.

Radiation from the Sun (solar radiation) passes through our atmosphere and is absorbed by the ground and oceans, warming them up. This energy is re-radiated (at a different wavelength) as heat into the atmosphere. Carbon dioxide and the other gases already mentioned absorb this heat energy, 'trapping' it. Some of this trapped heat will be re-radiated back to the surface. This would happen naturally, and it is very similar to the way in which heat from the Sun warms a greenhouse. The problem for us is that the steadily increasing levels of carbon dioxide in the atmosphere are increasing the amount of heat that is being 'trapped', so the temperature of the Earth is gradually rising.

pupils to list their sources (references) and *insist that they use more than one*. You might also suggest that at least one of these sources should be paper-based.

Restructuring as flow diagrams is particularly useful when pupils are being asked to carry out a practical activity (see also 'Sequencing', above). Even when both written and verbal instructions have been given to a class, there will be those who constantly ask what they have to do next! Asking them to convert the written instructions into a flow diagram format should force them to organise their thoughts and overcome this problem.

The conversion of text into flow diagrams is useful in many science contexts. Examples include the stages of industrial processes, biological processes such as digestion or blood circulation, the water/carbon/nitrogen cycles or (see Box 5) the Greenhouse Effect.

Research and note-making

As noted in Staples and Heselden (2001), note-making is at the interface between reading and writing. The literacy framework for key stage 3 identifies several core objectives that should be covered by more teachers than those in the English department. Some of these are particularly relevant to researching and making notes in science lessons (see Table 2).

An important focus of note-making must be to stop pupils simply copying out text, or worse (as mentioned earlier) downloading it from the Internet without actually reading it. A method frequently used to encourage pupils to note information from text is providing a series of questions that they have to answer. It is worth stating that when this method is used for note-making, pupils must either answer in

Table 2 KS3 literacy framework (DfEE, 2001).

Year	Learning objective
Year 7	Use appropriate reading strategies to extract particular information, e.g. <i>highlighting, scanning</i>
Year 8	Undertake independent research using a range of reading strategies; apply knowledge of how texts and ICT databases are organised and acknowledge sources
Year 9	Synthesise information from a range of sources, shaping material to meet the reader's needs

Box 6 Example of an empty KWL grid**The Human Lung**

What do I know about the human lung?	What do I want to find out about the human lung?	What have I learnt about the human lung?

complete sentences that make sense when read alone or have a copy of the questions so that question and answer can be read together. However, there are other ways of teaching research and note-making skills that will lead to greater independence.

Text marking and text restructuring are logical starting places for note-making. The text restructuring examples given above are clear examples of how pupils can extract information from their reading. Some of the examples listed also generate useful notes from which pupils can revise at a later date.

However, teachers need to steer pupils towards reading and extracting information independently. One starting point can be to use **KWL grids**. These sound frighteningly technical, but aren't! A KWL grid (Lewis and Wray, 2000: 34) covers pupils' prior knowledge, what they want to know, and what they subsequently learn. As an example, perhaps you want pupils to research the human lung. In their exercise books (or aided by a 'blank' pre-prepared by the teacher) pupils draw up the basic grid structure, with headings as shown in Box 6. In the first column of the grid, a pupil might write that they **know** that the lungs are situated in the chest and help you to breathe. They might **want** to find out how lungs work, so they would write this in the second column. Finally, they write what they **learn** about this, in note form, in the third column. It is simply one more way of getting pupils to read for a purpose and then organise their notes. Pupils can also generate grids like this at the start of a new topic, and then return to them at the end to complete the third column. **QADS grids** are a very similar idea, but cover **questions, answers, details** and **sources**. Box 7 shows an example of work generated using a QADS grid. Importantly for later Sel coursework, QADS grids encourage pupils to note down references/sources.

Completing the boxes in the second column of the KWL grid and the first column of the QADS grid

may require a certain degree of support from the teacher: pupils need to be taught how to ask useful questions without the teacher being relied on to provide them. The boxes in the third column in the KWL grid and the second and third columns of the QADS grid are the ones in which the pupils effectively make notes of what they have learnt. Using these frameworks can lead pupils towards independent note-making skills. The size of the boxes also helps able readers to be concise in their note-making and gives the less able an idea of how much information they should find. However, in the early stages, the teacher still needs to model how to make notes.

When you want pupils to make notes from a text, you need to talk about the *process* involved. If pupils have previously used text-marking DARTS you can show how to use the process of text marking as an initial way of extracting information from a text. You can then go on to show how to restructure this information into note form (if pupils have used restructuring DARTS previously they will understand this process better). You could demonstrate how to complete the third column of a KWL grid using bullet points. Alternatively, you could show pupils how to use mind maps to make notes, or how to group ideas using subheadings. Providing pupils with a blank 'framework' of one of these methods, to be filled in as they make their own notes, can be helpful. The aim, though, is ultimately to steer the pupil towards independent note-making.

An aside – the EXIT model

Teachers with a particular interest in the material contained within this article might like to familiarise themselves with the EXIT model. EXIT is yet another acronym, this time standing for **Extending Interactions with Text** (Wray and Lewis, 2000; DfEE, 2001). The EXIT model helps to identify the stages of the research process. The government's literacy

Box 7 Example of part of a completed QADS grid

(The work was generated by a year 8 pupil at Thorpe St Andrew School, Norwich.)

Rates of reaction

Questions	Answers	Details	Sources
What factors can affect the rate of a chemical reaction?	Concentration, temperature, and surface area can all affect reaction rate.	<p>The more concentrated the chemicals are, the more particles are present so they collide more often.</p> <p>The hotter the chemicals are, the faster the particles in them move, so they collide more often.</p> <p>The bigger the surface area of a solid chemical, the more chance there is of it being hit by other particles. This speeds up the reaction rate.</p>	<i>Key Stage 3 Revision Guide</i>
What is a catalyst?	A catalyst is something that speeds up a chemical reaction without getting used up itself.	Manganese(IV) oxide is a catalyst. It makes hydrogen peroxide decompose (break down) quickly into water and oxygen.	<i>Spotlight Science Year 8, pages 126–127.</i>

document (DfEE, 2001: 52) identifies the process stages, appropriate teaching strategies for each stage and the associated purpose. A copy of this document should be in every school. We have included a slimmed down version in Table 3.

The EXIT model clearly demonstrates the link between reading and writing. It is a formal recognition of the many processes (some of which may need to be specifically taught or demonstrated) that take place as a pupil progresses through a piece of research, from accessing individual prior knowledge, through several stages of active reading, to the eventual writing up of findings. It is also a reminder that the process of researching information is not as straightforward as a vaguely-set homework such as 'Research the elements' might suggest.

Sources of reading material

A major problem with encouraging pupils to do more reading in science lessons is the fact that science textbooks have become increasingly visual. They have moved away from pages of dense text with occasional line drawings to a format in which pictures, cartoons and white space sometimes predominate over the written word. Dean (2000) has pointed out that this type of layout, in which pictures and text are laid out

in blocks around the page, can cause problems for the reader. In particular, the readers may not actually know where to start reading, and it may be difficult for them to trace the normal left to right reading movements across the page. Furthermore, in an attempt to reduce the amount of written information many books are adopting an increasingly 'note-like' layout, with print arranged in short staccato bursts (Wellington, 2001). This makes it difficult to find continuous passages of text for pupils to read (or for teachers to turn into DARTs). To a large extent, some textbook publishers have sacrificed readability for 'modern' or 'attractive' layouts, and their books may actually be causing problems for readers (see 'Useful websites' listed at the end of this article). Where science departments have invested in textbooks that demonstrate some or all of these challenges, it becomes even more important for teachers to model the reading process as outlined earlier in this article.

Teachers can, of course, produce their own examples of continuous prose for use in the classroom (we had to for the DARTs given earlier), but there are also many other ready-made sources. Among the most obvious of these are newspapers, magazines, the Internet, and the large number of popular science books now available. Copyright restrictions allowing, all of these can provide rich veins of material for teachers to exploit in the classroom.

Table 3 The EXIT model (after DfEE, 2001).

	<i>Process stage</i>	<i>Teaching and learning strategies</i>
1	Activating prior knowledge	Brainstorm Concept map KWL grid
2	Establishing purposes	Question setting KWL grid QADS grid
3	Locating information	Teacher modelling Use of indexes, Internet, library, etc.
4	Adopting an appropriate strategy	Teacher modelling Skimming, scanning, close reading
5	Interacting with the text	Text marking Text restructuring Cloze Sequencing
6	Monitoring of one's own understanding	Teacher modelling Review of KWL/QADS grids
7	Making a record	Writing or note-making frames KWL/QADS grids Teacher modelling
8	Evaluating information	Discussion of the reliability of texts (particularly for Internet use) Challenge with outdated, biased or contradictory material
9	Assisting memory	Review Revisit Restructure
10	Communicating information	See text types in Staples and Heselden (2001) Speaking and listening activities

Summary

As we have shown, there are many different issues bound up in the literacy area of reading. The critical question to ask yourself when you are about to ask pupils to read is: What exactly do I want the pupils to gain from this part of the lesson? Once you are clear about your purpose, you can then select the reading

activity and the text or texts that will best support this. Shared reading may be all that is necessary in some instances, but in others it may be desirable to make the reading more active by structuring it as a DART. Regular use of a variety of DARTs can help pupils learn how to take effective notes from what they have read, and the use of KWL and QADS grids can further support readers on their journey towards becoming independent note-takers.

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Useful websites

A useful guide to the readability of science texts forms part of the website at:

www.timetabler.com

This shows the reading ages, the human interest scores (pictorial) and the human interest scores (personal words) for many of the science textbooks on sale in the UK. The section on key stage 3 textbooks is most relevant in the context of this article.

Information about the key stage 3 literacy framework is available at: www.standards.dfes.gov.uk/keystage3

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