

Children with communication difficulties in mainstream science classrooms

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This article explores some of the problems that children with communication difficulties face in learning science, its vocabulary and its own particular language. Practical ideas and strategies are suggested for helping to overcome these barriers in mainstream schools.

A brief history of inclusion

A mainstream schoolteacher starting her career in 1960 and ending in the 1980s will undoubtedly have met a wide range of pupils with different needs and interests. There is no such thing as a homogenous group. However, the range of needs that teacher would have encountered is certain to be far narrower than someone starting a career in the year 2002 (or even one who gained qualified status in 1995). There has been a succession of legislation in the UK, which has driven the policy of inclusion. It began with the Warnock report and the subsequent Education Act of

ABSTRACT

Central initiatives since 1981 have led to the current policy and practice of inclusive education. We speculate on the number of pupils with speech and language impairments who are present in mainstream classes and therefore the extent to which such difficulties will pose a challenge to science teachers in mainstream schools. We highlight and discuss the main barriers and challenges which language, communication and interaction difficulties will present to the mainstream science teacher and to the learner. Finally, we briefly outline a range of classroom strategies that science teachers can adopt at all key stages. These should help in lowering the language barriers and meeting the challenges that teachers were unlikely to encounter in the pre-inclusion era.

1981. This encouraged LEAs to integrate children with special needs into mainstream schools. Subsequent policy statements and legislation have reinforced the Warnock view and effectively widened the range of pupils in mainstream classes. In particular, the 1997 Green Paper, *Excellence for all children* (DfEE, 1997) accelerated the move towards inclusive education and ensured that a much wider group of professionals than speech and language therapists and educational psychologists would be certain to encounter specific speech and language impairments (SSLI) (see Table 1).

Since 1994, every school has been obliged to have a 'SENCO' (special needs coordinator). They perform a valuable role but their presence does not remove the need for classroom teachers to have their own awareness of the new range of pupils or knowledge of how to aid their teaching and learning. Science teachers will meet a wide range of potential 'difficulties', from physical disability to visual and aural impairment. One of the prevalent areas of special need which teachers are likely to encounter is that of 'communication and interaction difficulties'. Estimates vary as to the extent of language and communication difficulty in the 'average' classroom. As long ago as 1992, Beech (1992) estimated that at least two children in every mainstream class were experiencing marked difficulty with some aspect of communication.

More recent estimates of prevalence suggest a similar figure of around 7–8% of children with

Table 1 Some key events leading to inclusion (1981–2002).

<i>Event or publication</i>	<i>Effect</i>
1981 Education Act (based on Warnock Report)	Supported right of all pupils to attend local mainstream school Proposed abolition of 'categories of handicap' established by 1944 Act – in practice many categorisations, e.g. EBD, moderate learning difficulties, are still used Led to definition and use of term 'Special Educational Needs' (SEN)
1988 Education Reform Act	Introduced National Curriculum as a 'legal entitlement' for all pupils
1994 Code of Practice on the Identification and Assessment of SEN (DfEE)	Introduced to regulate and formalise the identification of SEN through the statementing procedure Led to some schools and parents demanding that children should be statemented as a means of increasing resources for support for that individual
1997 DfEE green paper, <i>Excellence for all children: meeting SEN</i>	Affirmed the desirability of all children attending their local school in principle
1998 DfEE paper, <i>Meeting SEN: a programme for action</i>	Rekindled long-running debate about 'integration' and 'inclusion'
2001 Code of Practice from 1994 revised	Should speed up process of identification and assessment of special need by reducing number of stages involved from 5 to 3
2002 The SEN and Disability Act	Strengthens rights of parents to insist on a mainstream place for their disabled child

(Source: e-mail from Dr Felicity Armstrong and various articles in *British Journal of Special Education*.)

language difficulties of varying severity (Dockrell and Lindsay, 1998) with some estimates as high as 10% (Law *et al.*, 2000). On this evidence, every school in the UK will have (on average) at least one child in every class with a language and/or communication difficulty, and this number will certainly be higher in areas of social disadvantage. In addition, we feel that there are many children with some form of communication and interaction difficulty and therefore that many of the strategies we outline later should be applied as general practice.

To sum up, the drive towards inclusion has increased the prevalence of communication difficulties in the mainstream science classroom.

Improved diagnosis (and perhaps the wider publicity given to, for example, autism and dyslexia) has also heightened general awareness of the issue.

Twenty years on from Warnock, recent research (Dockrell and Lindsay, 2001) showed that mainstream teachers face several challenges as a result of inclusion. These include: encountering for the first time SSLI for which they have had no training; consequently, a lack of understanding of children with these problems; in turn, a lack of ideas of how to handle such pupils in the classroom and to meet their special needs, aggravated by a lack of expert language support. Dockrell and Lindsay (2001, p. 389) report teachers' feelings of inadequacy and frustration as a

result. Teachers need appropriate training (both pre and in-service) and appropriate support and collaboration, e.g. with speech and language therapists (SLTs). This article is written with those needs in mind.

What can be said about the precise nature of the difficulties and their influence on the learning and teaching of science?

Specific speech and language problems: learning and teaching science

In this section, we look at a range of difficulties, showing how they present themselves and how their presence impinges on science education.

1 Problems with speech production

A pupil with poor speech production will be unable to show her or his understanding in a classroom situation, whether it be in a whole-class question-and-answer session or in small-group situations. An apparent learning difficulty may therefore be caused by this communication difficulty, not a cognitive difficulty. Also, speech production problems will also make it harder for a teacher to ascertain a student's level of prior understanding. SSLI pupils will have problems in learning, saying, writing and storing scientific words, especially complicated, polysyllabic ones.

2 Word-finding difficulty, connected with problems in learning, storing, and retrieving words

We all have occasional difficulties in finding words when we most want them. Some children have severe word-finding difficulties and this interrupts their language and thought processes. The difficulty in retrieving words is related to problems with how they are stored in our minds – our 'store of words' is known as our *lexicon*. Children with SSLI may have difficulty in retrieving words from this store or lexicon. This may also be noticeable in their language, as word-finding difficulties are often linked or associated with speech difficulties.

3 Learning specialist vocabulary

The above problem is connected with a difficulty in learning the vocabulary of science. As all science teachers know, the subject has a terminology of its own and the difficulties for all pupils in acquiring it

have been well researched and documented (see Wellington and Osborne, 2001, for a summary). This difficulty can be much greater for pupils with SSLI. They tend to learn a word and its use in one context and find it very hard to transfer its use to another context, i.e. their understanding of a word is very *context-specific* or 'situated'. This poses acute problems for those scientific words that have a meaning in everyday life and also a specialist, exact, specific meaning in science. Words such as 'power', 'energy', and 'work' spring to mind. There is evidence to show that many pupils are capable of switching from one domain to another (everyday to scientific and vice versa) in their use of language and of 'alternative frameworks' – this switching ability should not be taken for granted with SSLI pupils. This may also result in rigid, inflexible use of equipment. For example, SSLI pupils may have difficulty in grasping that a piece of apparatus, e.g. a clamp or a test-tube, can be used in more than one context or situation.

They may also have problems with similar-sounding words (e.g. rabies and rabbis) and may *lexicalise*, that is, make a new word into a word they already know, e.g. spear for sphere.

Other words in science are often used in a metaphorical rather than literal sense – the idea of a 'field' is one example. Children with SSLI and (as we see later) autistic spectrum disorders often have difficulty in using language metaphorically and in analogy. Lateral and metaphorical thinking, which is an essential part of science, is therefore a problem, e.g. 'seeing things as ...' or 'imagining this is like ...', or 'looking at X as if it were ...' This is related to a more general difficulty mentioned later in discussing autistic spectrum disorders. Children with SSLI may have difficulty in both understanding and using language appropriately in a particular context (Farmer, 2000). They may not know when someone (e.g. a classmate or the teacher) is joking, being ironic or worse still sarcastic, or using analogy or metaphor. Since analogy and metaphor are such a central part of science teaching, and indeed science itself, this poses another barrier to many pupils.

4 Joining words together to form meaningful language

Problems in sequencing and joining come at several levels. Sounds need to be sequenced and joined to form words, words must be ordered and conjoined to form sentences, and sentences need to be sequenced in order to make spoken or written language have

meaning. Pupils with SSLI may not be capable of putting a sentence together in an appropriate sequence, or a series of sentences together to explain an event or a process.

5 Language and scientific reasoning

Sequencing and joining is an essential part of science – to understand a process of any kind (from photosynthesis to the formation of rocks or fossil fuels) there needs to be a sense of chronology, i.e. one thing coming after the other. Ordering and sequencing are also an essential skill in understanding ‘cause and effect’ relationships, i.e. the notion of causality, which is such a crucial idea in science. This can present huge difficulties for a pupil with a language disorder. Their general understanding of time can be a major problem.

This problem is linked with the difficulty of drawing inferences. It is hard to make inferences without a notion of sequence (X follows on from Y) or the notion of causality (A causes B to happen). Again, inferential thinking is a key part of scientific reasoning. Similarly, the ability to predict, vitally important for science, depends on the ability to perceive and conceptualise time differences, chronology, sequence, and causality. For many pupils with SSLI, the art of prediction in science may be a higher-level skill than we give it credit for – it is certainly not to be taken for granted.

A further problem for some pupils may be a difficulty in grasping the idea of a ‘variable’, especially if they perceive and understand things in a very context-specific way. This will obviously mean that they find the notion of ‘control of variables’ difficult and the idea of a fair test will not be intuitive.

More generally, all scientific verbal reasoning (and reasoning in other subjects) requires language. For example, children need language to think through a problem (either on their own, or in small group work). If this language presents a difficulty, then so will reasoning and problem solving.

6 Social communication and interaction

Social communication and interaction, e.g. responding to the verbal or non-verbal cues of others, can be a particular problem in group work in science, especially when pupils are carrying out collaborative tasks which require teamwork and cooperation, e.g. practical activities and investigational work. It shows itself in problems with social interactions such as ‘turn taking’ and the use of social language. As Vygotsky

once put it: ‘*Children solve practical tasks with the help of their speech as well as their eyes and hands*’ (Vygotsky, 1978). If the speech and social interaction is a barrier this will show itself in practical and group work.

7 Difficulty in understanding relational concepts and abstract concepts

This presents a particular difficulty for learning science. Many of the key concepts of science are necessarily abstract – this is why they are powerful and useful in a range of contexts. Science also deals with idealised entities (such as frictionless surfaces and point masses) which are not found in reality. The abstract nature of science is a difficulty for all pupils but may pose an additional barrier to those with language difficulties. Relational concepts or ‘relatives’ such as heavy/light, large/small, massive/not massive, inert/active and so on will also pose difficulty. Pupils will find difficulty not only in acquiring but also in *expressing* thoughts, ideas and concepts.

8 Problems in following instructions

Again, experienced science teachers will chuckle at this one, which seems to afflict all pupils, especially on wet, windy Friday afternoons. This may well be a serious difficulty for pupils with SSLIs, if they have problems with the functioning of their auditory memory. Some are unable to follow instructions, especially if they involve a chronological sequence and the concept of causality, i.e. X follows Y, which in turn causes Z. Many pupils have difficulty in following instructions given verbally, even if these are given in writing as well as orally, i.e. giving both spoken instructions and written ones on the screen or board may not be sufficient. Some may also need pictures and symbols (such as the Rebus symbols shown in Figure 1). Difficulties in remembering and storing instructions mean that some pupils cannot follow more than one instruction at a time, and by the time they have done one task they may have forgotten what is required next (Nation *et al.*, 1999). To sum up, pupils will have difficulty in following and carrying out instructions if they are too long, too complex or involve the notions of sequence and causality.

9 General lack of progress in literacy

Not surprisingly, there is strong evidence that children with language difficulties also experience literacy difficulties (Botting *et al.*, 1998). Children with written language difficulties, such as dyslexia, experience

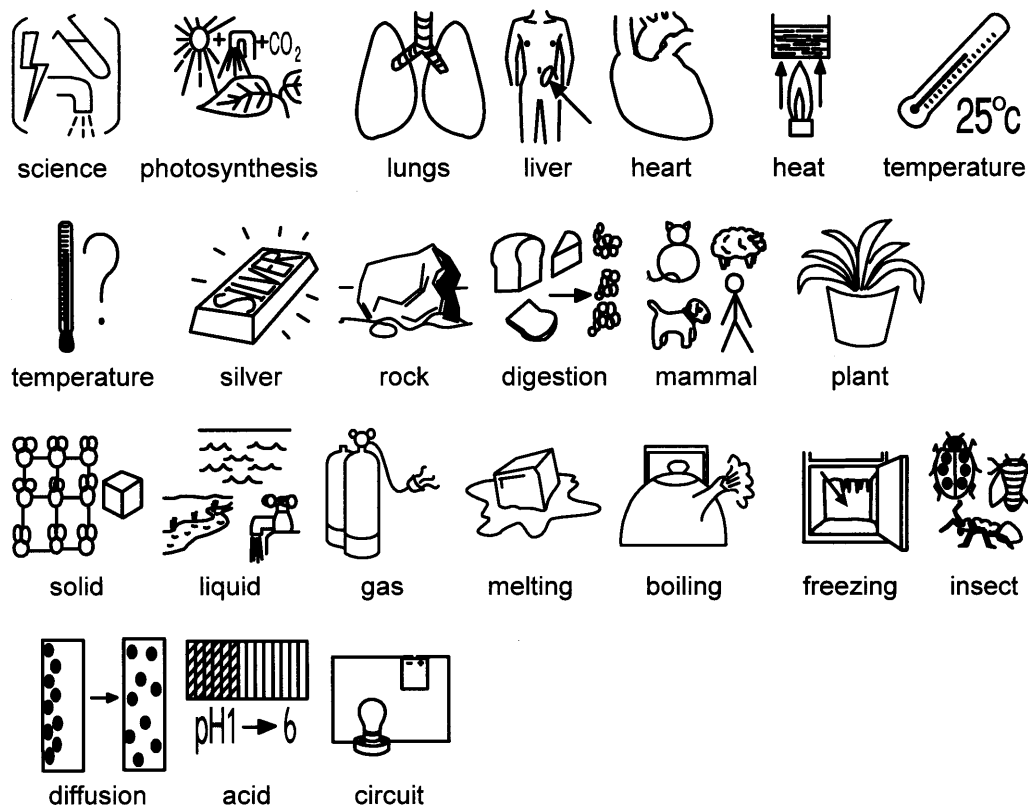


Figure 1 Rebus symbols from Widgit Software (Rebus and PCS symbols used with kind permission of Widgit Software Ltd, telephone 01926 885303).

some form of spoken or perceptual language difficulty. Lack of progress in literacy will result in problems with independent research, with note taking, reading, use of the Internet and many other activities related to science education.

Autistic spectrum disorders (ASD)

A further list of challenges or difficulties occurs when we consider autistic spectrum disorders (ASDs). Estimates vary as to the prevalence of ASD in school-age children. The most current estimate available (December 2001) is that approximately 8 people in 1000 (about 0.8%) are affected by some degree of autistic spectrum disorder (further details and discussion can be found on the excellent website of the National Autistic Society at www.nas.org.uk).

A long list of challenges posed by ASD includes the following elements, all of which relate to the

experience of science teachers:

- 1 Problems in attuning to social situations: as noted already, pupils may have problems with social interaction, responding to verbal and non-verbal cues and using 'social language'. This may also mean that they do not respond to humour, e.g. use of a pun or other joke, irony, or certainly sarcasm. Pupils may show inappropriate social behaviour, perhaps leading to rejection by peers.
- 2 Pupils may interpret instructions literally.
- 3 Pupils may have their own personal agendas during a lesson and go off entirely on their own track. The old phrase 'he's got a mind of his own' may have a more poignant meaning than usual in this context. Many experienced teachers will have stopped pupils from melting their plastic pen in the Bunsen flame or from deliberately blowing fuses. But pupils with ASD may have more 'personal agendas' than most, which they may follow in practical work but also in doing some

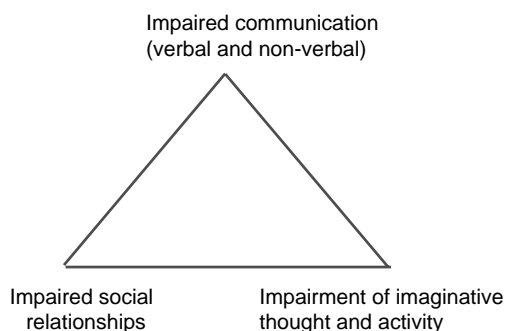


Figure 2 The triad of impairments associated with autistic spectrum disorders (ASD). (Source: Frith, U. (1989) *Autism*, triad based on the work of Lorna Wing)

research or searching for information, e.g. on the Internet.

- 4 Obsessive behaviours: many pupils may become completely engrossed in a certain topic or line of enquiry, and this is often to be welcomed. This happens with many topics and ‘The Dinosaurs’ is probably the classic – but some pupils with ASD may become totally obsessed with one aspect of science, e.g. the Periodic Table. This obsession may then impede their learning in other areas.

These so-called disorders related to the autistic spectrum can be represented in the form of a triad (see Figure 2).

One of the key features of autism, which impinges on science learning and teaching, is a tendency to interpret language (spoken but also written) *literally*. This is caricatured in the recent advertisement which runs:

Person 1: ‘*Have you got a light?*’

Person 2: ‘*Yes thanks*’.

This is a particular problem for science. Science teachers depend on the use of analogy in order to explain difficult ideas and abstract concepts. They use the water analogy to convey the idea of a current or a flow – this analogy is sometimes taken further in likening a cell or battery to a pump, which ‘pushes’ water around the circuit. Resistance has been taught in a similar way, e.g. relating it to the width of a water pipe. The water analogy has its critics, which we cannot go into here. But this, and other analogies and metaphors, are widespread in science teaching. We talk about a ‘sea of air’ above us in explaining atmospheric pressure, we use the idea of a field, we talk about light as being a wave (and a particle in

explaining a phenomenon like photo-electric effect) and we sometimes attribute human characteristics to non-human objects (anthropomorphism) in order to make scientific ideas more accessible. There is no doubt that some pupils will take these literally. For example, in science teaching for one pupil the digestive system had been likened to a washing machine and as a result he literally thought that food is washed during digestion. Science teachers cannot avoid metaphor – physics, especially, depends on it. But in teaching via metaphor and analogy science teachers need to be extremely vigilant in ensuring that they are taken as such and not interpreted literally – this requires use of phrases like ‘we can see X as if it were...’

In the next section we turn to a discussion of other practical strategies.

Classroom strategies

The first step is to be aware of some of the difficulties that these children encounter and we hope that this article contributes in a small way to that awareness. We cannot provide a detailed set of teaching ideas or resources here (in fact, there are several good resources on the market which teachers can draw upon). All we can do in this last section is to present some general strategies and guidelines that can be followed. One of our messages so far is that many of the difficulties presented above apply equally to all members of a mainstream class at some time or another, in varying degrees. Taking metaphor and analogy literally, not following instructions, having their own ‘personal agenda’, not always communicating or interacting appropriately with peers, and problems with literacy are hardly out of the ordinary. However, SSLI and ASD pupils’ difficulties will be more frequent and severe and they may also have the other difficulties outlined in the last two sections above.

Our overriding theme is that ‘what’s good for the goose is good for the gander’. The strategies we suggest can be applied to all – they are ‘good practice’ anyway. Many teachers will already be putting them into practice. On top of these, we suggest that science teachers facing pupils with communication difficulties should consult the SENCO and as a result the speech and language therapist connected with the school who can then work collaboratively with the teacher to develop specific resources and strategies (Popple and Wellington, 2000).

The strategies we suggest are:

1 Adopting a multisensory approach

This will give all pupils the opportunity to learn in a way suited to their learning style and ability. This approach involves using a range of communication methods, including speech, images, graphs, charts, pictures, diagrams, pictograms, and symbols. Multi-media, e.g. from CD-ROM or the Internet, can also be valuable. Using verbal language only, i.e. the spoken or written word, is not sufficient. All diagrams, display, illustrations and visual aids, e.g. on whiteboards or from OHPs, need to be clear and uncluttered, not overpowering or daunting. Concepts need to be put across using a range of media and senses, including (for example) body activities and movements to show processes such as digestion. Similarly, opportunities need to be created for outputs in different forms. For example, pupils' work and reports could be recorded and presented in different media, e.g. on computers, using video or audiotape, as photographs from a digital camera.

2 Concept acquisition and explanation

Teachers (and textbook or worksheet writers) should avoid trying to introduce more than one concept at the same time. Planning for small steps and some opportunity for repetition and reinforcement ('over learning') is essential. A wide range of numerous concrete examples is needed for concept learning to occur.

3 Learning and teaching with words

Sentences (spoken and written) need to be kept as simple as possible, being wary of jargon. In giving instructions, keep them simple and straightforward and avoid changing the wording of an instruction or an explanation – this can confuse many pupils. Technical words (especially those denoting abstract or relational concepts) need to be introduced and explained several times – verbal explanation is not enough. Images, pictures, pictograms and other media will be needed. New words should be highlighted and 'made a meal of', giving key words for a topic in advance of a lesson – ideally, starting from the pupils' own language to act as a hook. For example, in teaching concepts of size we may need to start with words and ideas such as 'big' and 'little'.

4 Consistency and predictability

This is good practice for any classroom management, but is particularly important for SSLI or ASD pupils.

Classroom routines need to be consistent to avoid creating anxiety. For example, a consistent format and set of procedures for practical work will encourage pupils' feelings of being safe and confident. Similarly a consistent presentation of written or visual material will develop confidence. Storage of equipment needs to be constant and consistent, and done in a logical way. Storage spaces need to be clearly labelled with words and symbols (colour coding will help here) and regularly reiterated to pupils. Lab rules need to be clear, logical and consistent.

5 Other strategies

A range of other, general strategies can be employed. Tables 2 and 3 provide a summary of several strategies and how they relate to particular difficulties with speech and language.

Glossaries, dictionaries and word banks will help all pupils but especially those with language difficulty. Pupils can build up their own personal glossary of words, with their own drawings and images. Presenting on paper and displaying key words in advance of teaching a topic, and then giving instruction on pronouncing them, can relieve anxiety and pre-empt some difficulties, e.g. spelling, storage and use of these words. Polysyllabic words can be broken down into their parts (this also shows their roots with stems such as photo- and trans-) and re-assembled to help with memorising, spelling and pronouncing them. Directed Activities Related to Text (DARTS) are well tried and tested now and their use, e.g. in supporting and structuring active reading, will be especially valuable with SSLI pupils. Similarly with output – writing frames are now common and will be valuable in scaffolding and supporting writing. Figures 3 and 4 show some examples currently in use at primary and secondary level. (All of the above strategies and tactics are discussed in Wellington and Osborne, 2001, especially pp. 122–130).

Concluding remarks

Our final comment is that teachers should work collaboratively with the SENCO in the school and the speech and language therapist wherever possible. In the classroom, the value of helpers and assistants in mainstream teaching should also not be underestimated. By collaborating effectively, science teachers can work with support to improve learning and teaching for SSLI and other pupils (for further discussion, see Wellington and Osborne, 2001, p. 136


Table 2 Receptive language disorders, consequences and strategies.

<i>Problem</i>	<i>Consequences</i>	<i>Strategies</i>
Receptive language disorders (in general)	Affects learning in all areas of the curriculum Difficulties with learning new skills and generalising knowledge	Use language at an appropriate level
Poor understanding of vocabulary	Poor comprehension of instructions Poor comprehension of group teaching Poor acquisition and use of vocabulary Poor ability to access topic work	Use consistent vocabulary Teach vocabulary repetitively, and before used in lesson Use visual support, e.g. signs and symbols, and 'hands on' whenever possible Teach small numbers of words at a time Relate new vocabulary to words already known – give it a context Relate to category words, e.g. animals
Poor understanding of concepts	Affects all aspects of the curriculum Particularly affects science and maths Lack of appreciation of relativity, e.g. long, heavy Poor appreciation of time, e.g. before, later, yesterday	Teach using visual support, written word and experiential learning Teach concept with related object words, e.g. 'wet' – rain, bath, water. Teach in a comparative situation, e.g. long vs. not long, long vs. short Use visual timetables and calendars to explain time and sequences
Poor understanding of syntax	Poor understanding of instructions and explanations Poor understanding of question words Difficulty with tenses and plurals Difficulty reading and understanding	Simplify sentence structures used Relate question words to clues, e.g. 'Where?' is about <i>places</i> , 'Who?' is about <i>people</i> Reinforce with ideas from the literacy strategy
Slow or inaccurate processing of verbal information	Poor attention – loses track of what is happening in the classroom	Gain the child's attention before speaking Allow time for the child to process language. Visually organise materials and visually explain tasks
Difficulties with higher language skills, e.g. ■ Making inferences ■ Literal interpretation of verbal language	Affects socialisation Poor understanding of jokes, humour, sarcasm Affects prediction of text in reading Affects exponential ('vertical') learning, e.g. science, maths	Make connections and explain as situations arise Teach meaning of question words Social communication groups

Table 3 Speech disorders, consequences and strategies.

<i>Problem</i>	<i>Consequences</i>	<i>Strategies</i>
Difficulty in being understood	Difficulties with speaking and listening, conversation, joining in, play, social situations; teacher has difficulty in checking on the pupil's learning and understanding	Encourage visual support, including natural gesture, signing and use of symbols, e.g. Rebus (see Figure 1) Allow time to contribute to class discussions
Difficulties with auditory processing (there is a two-way link between auditory processing and auditory memory)	May take a long time to assimilate, understand and act on spoken information	Allow time to process spoken information Offer information in small chunks Use visual support If repetition is needed, retain the same vocabulary, but simplify structure and length
Poor auditory memory	Affects all areas of the curriculum and independence skills	Keep instructions short Use visual support
Difficulties with breaking down words into smaller units, e.g. ■ Rhyme ■ Blending ■ Beginning and end sounds ■ Syllables	Poor literacy development and difficulty in moving from one development stage to another.	Encourage multisensory learning Use visual support Develop phonological awareness (of sounds within words) and ability to say them
Poor organisational skills	May be sequencing/organisational difficulties at the level of: ■ Sounds ■ Words ■ Ideas ■ Social organisation	Strategies include: ■ Phonological awareness ■ Visual support ■ Rehearsal of sequence of actions ■ Visual timetables, story boards, and writing frames

LINK Topic 5: Sequencing events **Folding mini-book 1**



<p>This is what happened...</p>	<p>This is how we kept it fair...</p>
<p>Here is a picture of what we did.</p>	<p>MY INVESTIGATION BY</p>

Figure 3 A frame to help in sequencing (from Feasey, 1998).

name	date
title	
Definition	
A is	
Details	
It belongs to a group/family of living things called	
Characteristics	
Appearance <i>What does it look like?</i>	It is
Habitat <i>Where does it live or grow? Why?</i>	It lives/grows
Life span/life cycle <i>Birth, growth, produces offspring, dies.</i>	It began life as
Nutrition <i>What does it 'eat'?</i> needs food in order to live and grow. It needs
Conclusion – a final sentence or sentences	
.....	

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Figure 4 An example of a writing frame for science (from Lewis and Wray, 1998).

onwards). All of the practices that might stem from such collaboration, including those outlined above, are good practice in teaching and learning anyway.

We should never make hasty assumptions about pupils – the presence of language or other related difficulties does not imply that a child cannot learn science.

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