

Teaching science in a meaningful way: striking a balance between ‘opening up’ and ‘closing down’ classroom talk

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As well as providing a first step to supporting meaningful learning, dialogic engagement is potentially motivating for pupils

Teaching science involves introducing pupils to the ways of talking and thinking of the scientific community. Take the case, for example, of teaching a group of key stage 3 pupils (11–14 year-olds) about the basic working of electric circuits (including the concepts of current, energy and resistance). How do we move from a situation where the pupils understand little or nothing about these ideas to one where they are able to talk and think about them for themselves? The intervening teaching sequence is likely to include various different activities, such as pupil practical work, a teacher demonstration, maybe use of a computer simulation, and so on. Whatever the activities used, however, a central feature of the lesson sequence must be the interactions, or talk, between teacher and *pupils*. It is through this talk that the scientific story is introduced.

This may seem obvious! How else can we teach science apart from interacting with pupils? However, these interactions are all too often ignored or taken for granted in a teaching sequence. Particular approaches to teaching electricity are spoken of in terms of this activity or that, but rarely in terms of the ways in which the classroom talk is developed

ABSTRACT

This article makes the case that teaching to support the meaningful learning of science must involve both dialogic (‘opening up’) and authoritative (‘closing down’) approaches. Attention is drawn to the underlying teaching skills involved in such teaching and this is illustrated by reference to a sequence of lessons on forces with 10–11 year-olds (year 6).

over a sequence of lessons, employing a range of different approaches.

This article attempts to redress the balance a little by offering a report from an ongoing research project (Mercer, *et al.*, 2006) focusing on the different ways in which teachers frame classroom talk in introducing new scientific ideas to pupils. In particular, we argue that, in order for meaningful learning to result from a sequence of science teaching, teaching must involve both *dialogic* (‘opening up’) and *authoritative* (‘closing down’) communicative approaches. The argument builds upon these theoretical ideas (Mortimer and Scott, 2003) and is illustrated with empirical data from a sequence of lessons on forces with 10–11 year-olds (year 6).

First, the idea of the communicative approach is introduced, before turning to the analysis and discussion of the forces lessons.

The communicative approach

The concept of the communicative approach was first introduced by Mortimer and Scott (2003) and provides a perspective on *how* the teacher works with pupils to develop ideas in the classroom. It focuses on questions such as whether or not the teacher interacts with pupils (teacher and pupils taking turns in the classroom talk), and also on whether the teacher takes account of pupils’ ideas as the lessons proceed. The communicative approach is defined by characterising the talk between teacher and pupils along each of two dimensions: *interactive–non-interactive* and *dialogic–authoritative*.

Interactive and non-interactive

What is meant here by an interactive approach to teaching? Put simply, *interactive* teaching allows for the verbal participation of both teacher and pupils and *non-interactive* teaching involves only the teacher. Thus in interactive teaching the teacher typically engages pupils in a series of questions and answers, whilst in non-interactive teaching the teacher presents ideas in a 'lecturing' style.

Dialogic and authoritative

What is meant by a *dialogic* teaching approach? The idea here is that the teacher asks pupils for their points of view and explicitly takes account of them by, for example: asking for further details ('*Oh, that's interesting, what do you mean by ...*'); or writing them down for further consideration ('*Let's just put that down on the board, so that we don't forget it ...*'); or asking other pupils whether they agree with the ideas or not ('*Do you go along with what Julia has just said ...?*'). In short, the teacher makes room in the classroom talk for a whole range of ideas. In dialogic talk there is always the attempt to acknowledge the views of others, and through dialogic talk the teacher attends to the pupils' points of view as well as to the school science view.

Of course, classroom talk is not always dialogic in form. There are many occasions when the teacher is not interested in exploring pupils' ideas and taking account of them in the development of the lesson. Here the teacher is likely to focus on the science point of view; if ideas or questions that do not contribute to the development of the school science story are raised by pupils, they are likely to be reshaped or ignored by the teacher. This kind of talk is *authoritative* in nature.

Four classes of communicative approach

The two dimensions identified above can be combined to generate four ways in which the teacher might communicate with pupils in the classroom. Thus any episode of classroom talk can be identified as being either *interactive* or *non-interactive* on the

one hand, and *dialogic* or *authoritative* on the other, generating four classes of communicative approach (Mortimer and Scott, 2003) as shown in Figure 1.

The four classes can be briefly characterised as follows (see Scott and Asoko, 2006):

- A** *Interactive/dialogic*: teacher and pupils consider a range of ideas.
- B** *Non-interactive/dialogic*: teacher reviews different points of view.
- C** *Interactive/authoritative*: teacher focuses on one specific point of view and leads pupils through a question-and-answer routine with the aim of establishing and consolidating that point of view.
- D** *Non-interactive/authoritative*: teacher presents a specific point of view.

How might the idea of the communicative approach be used in analysing the interactions between teacher and pupils in the lessons on forces?

Teaching about forces

The following teaching and learning episodes were observed in a year 6 science class in a primary school in a semi-rural setting in the north of England. The teacher, who we shall refer to as Mrs Simon, is a not a science specialist. She has worked in this particular school for nearly 20 years and is highly regarded professionally by her colleagues. Mrs Simon taught the year 6 class for all subjects and at the time of the observations (early March) knew the pupils very well and enjoyed teaching them. Mrs Simon rated the class as being of about average ability. The class was observed and video-taped for three 90-minute science sessions, each taking up one full afternoon per week.

Episode 1: What do you understand by the word 'force'?

We join the science class right at the start of the first lesson. The pupils are sat at their tables and Mrs Simon begins by posing a question:

| | Interactive | Non-interactive |
|----------------------|---|---|
| Dialogic | A <i>interactive/dialogic</i> | B <i>non-interactive/dialogic</i> |
| Authoritative | C <i>interactive/authoritative</i> | D <i>non-interactive/authoritative</i> |

Figure 1 Four classes of communicative approach.

1. **Mrs Simon:** *Today, we are going to talk about forces. What do you understand by the word 'force'? Any meaning that you can think of ... what does the word 'force' mean? Think of other words that might explain what the word 'force' means.* [Several pupils put up their hands and Mrs Simon nominates Gareth.]
2. **Gareth:** *Hmm ... push and pull.*
3. **Mrs Simon:** *Ah ... let's put it down* [writes the words 'push' and 'pull' on the flipchart]. *Anything else that might describe what the word means?*
4. **Ellie:** *Move something.*
5. **Mrs Simon:** *Move something* [writes on the flipchart].
6. **Louis:** *Like hmm ... hold 'cos like gravity* [inaudible].
7. **Mrs Simon:** *Let's put that 'hold'* [writes on the flipchart]. *Anything else? If you are thinking of a particular meaning – if you are thinking of the word force, then how would you use the word force? Not just in science ... 'cos you are not always using it in a scientific way.*

During the next nine turns there is discussion of the idea of 'forcing or making somebody do something'. Max then offers a different idea:

17. **Max:** *Hmm ... like power – like the force of the heat or the power of the heat.*
18. **Mrs Simon:** *Power is the word* [writes the word on the flipchart]. *Anything else that might go with the word 'power'?*
19. **Larry:** *Like power of the storm.*

By the end of the interactions, which continued for another seven turns, the following list of ideas is on the flipchart:

*Push and pull, Move something, Hold,
Make something to do, Power, Strength, Speed.*

Analysis

In this episode, Mrs Simon invites the pupils to offer ideas that they have in relation to the word 'force'. She accepts these ideas with little comment and lists them on the flipchart, whether they relate to the scientific point of view or not. In this way the teacher takes an *interactive/dialogic* communicative approach in working with the class.

Episode 2: Looking at the meaning of the word 'force'

Mrs Simon now turns her attention to the entries relating to the word 'force' in two dictionaries:

Mrs Simon: *Right! What I've done here is to photocopy the entry from our dictionary ... and*

there are two different entries from two different dictionaries, and we're looking at the meaning of the word force ... Let's look at this first one first ... So, the first meaning of the word force ... is the couple of words we got up here [pointing to the flipchart]. *Power, strength, intense effort – the reason I'm giving you this is because I want you to think about all the different ways the word is used, and to just help you to understand what the word means. The second use of the word is force when it is used as a group of soldiers or a group of policemen like we talk about police force. Yes? You got it? The third way is cohesion, compulsion – to coerce someone is really when you make someone do something* [pointing to flipchart].

Analysis

This brief episode is clearly *non-interactive* in form (as Mrs Simon does all the talking). It is also *dialogic* in the sense that Mrs Simon reviews a range of ideas relating to the word force, in no way restricting her attention to just one meaning. In this way she takes a *non-interactive/dialogic* communicative approach. At first glance, the notion of a *non-interactive/dialogic* communicative approach may seem a little odd. How is it possible to have a dialogic approach involving just one person? The key point here is that the dialogic approach does not depend upon the number of people involved but on whether or not the talk focuses on just one idea (in which case it would be authoritative) or a range of ideas (when it is dialogic, as in this case).

Episode 3: Is it scientific or not?

In the next activity, Mrs Simon organises the class to work in small groups to discuss whether particular usages of the word 'force' are scientific or not: 'force the door open' [yes]; 'force of habit' [no]. Mrs Simon then organises a plenary session where the groups report their views on some of the items. We join the class as they are considering the expression, 'the force of the storm':

1. **Mrs Simon:** *The second one then, the force of the storm did a lot of damage to the building.* [Some pupils put up their hands and Mrs Simon nominates Amy to answer.]
2. **Amy:** *We think that one is scientific 'cos it's like a push ... of the storm that did the damage.*
3. **Mrs Simon:** *Do you agree with that?*
4. **Ottie:** *We think 'no'.*
5. **Mrs Simon:** *You think 'no' – so you disagree with what they say? Can you tell me why?*

6. **Ottie:** *Because, like hmm ... force ... if it is like – well that is – that's got the power of the storm ... I think, the power of the storm, it's not pushing of the storm. Yeah! It's the power of the storm.*
7. **Mrs Simon:** *What do you think then?*
8. **Ellie:** *I think it is, because the power of the [inaudible].*
9. **Mrs Simon:** *So you disagree with Ottie?*
10. **Ellie:** *Yeah! 'cos like [inaudible] the power of the push – it's like saying that the power of the push did a lot of damage to the building ... 'cos it's hmm ... 'cos it won't be due to the force of making you do something ...*
11. **Mrs Simon:** *What do you think about what she said there [inviting other pupils to respond to Ellie's answer]?*
12. **Eden:** *I think Ellie is right – we think it is, 'cos [inaudible].*

Analysis

This discussion of the meaning of 'the force of the storm' continued in this way for another 17 turns. Some pupils support Amy in making a connection to the 'push' of the storm and argue that this is a scientific usage. Others agree with Ottie in suggesting that here the word 'force' means the 'power' or 'strength' of the storm and in this sense is not being used in a strictly scientific way.

Throughout these exchanges Mrs Simon takes the role of prompting/inviting contributions from the class: 'Do you agree with that?' 'So you disagree with what they say?' 'What do you think then?' In this way, Mrs Simon says rather little and it is the pupils who make extended responses as they outline their ideas. Another feature of these interactions is the way in which the pupils comment upon and evaluate each other's points of view. Using a technical term, there is a high level of *interanimation* of ideas (see Scott *et al.*, 2006). This is in contrast with the first episode where the ideas are simply brought out into the open (and listed on the flipchart) with no further discussion or interanimation of views.

Overall, it is clear that this episode is played out through an *interactive/dialogic* communicative approach as different ideas are discussed by teacher and pupils.

After a great deal of animated discussion, Mrs Simon draws the plenary to a close. In the final part of the lesson the pupils go outside into the school yard where they use various pieces of sports equipment to demonstrate pushes and pulls in action ('the bat pushes the ball', 'I pull the rope').

Episode 4: What are forces?

This episode takes us to the beginning of the next lesson, in the following week. Mrs Simon starts with a review:

1. **Mrs Simon:** *You had a good go at thinking about forces. Just to remind you of what you – or you to remind me of what you got up to last week – what are forces?* [Several pupils put up their hands and teacher nominates Jessica to answer.]
2. **Jessica:** *A push or a pull?*
3. **Mrs Simon:** *Yeah! Pushes and pulls ... and forces, we, I'll just summarise what we did last week actually. Forces are needed to start things moving. Think about the things we did out in the yard. What else might they be used for?*
4. **Becky:** *Stop things moving.*
5. **Mrs Simon:** *Stop things moving. Can you think of any time when they stopped things moving? Give me an example of something that stopped ... something else moving ... last week?*
6. **Lyndon:** *A cricket bat stopped the ball.*
7. **Mrs Simon:** *The bat stopped the ball. And what else did forces do? In some of the activities? In this one [pointing again at Lyndon to refer to the cricket bat]. Mark?*
8. **Mark:** *The bat pushed the ball, once it stopped the ball it pushed it away.*
9. **Mrs Simon:** *How might you describe that? What did it do to the ball?*
10. **Becky:** *Maybe it stopped it and then it started it again.*
11. **Mrs Simon:** *Yeah! How?*
12. **Connie:** *Is it rebounding off it?*
13. **Mrs Simon:** *Kind of. How might we say that? How might we describe that movement? Ball comes from the bowler's hand to the bat ... what else is it doing to the ball?*
14. **Alex:** *Bouncing?*
15. **Mrs Simon:** *Hmm ... Yeah! Yeah! What ... how can we ... how else might we describe that?*
16. **Lyndon:** *It pushed it. It pushed the ball.*
17. **Mrs Simon:** *It pushed it from the bowler, didn't it? How did it change, once it's been stopped?*
18. **Becky:** *Direction.*
19. **Mrs Simon:** *It changed direction, didn't it? And at the end of last week we talked about measuring forces, how we might sometimes need to measure a force, and how we might sometimes need to consider the direction of a force. And I want to go on today to look a little bit more about directions of forces and also measurements of forces, and ... thinking all the time ... What forces are in action? What's happening here? What's making*

something start? What's making something stop? What's making something change direction? All right? Think about that all the time.

Analysis

The nature of the talk in this episode is quite different from the previous ones. Mrs Simon starts by asking the class, 'What are forces?' Jessica replies, 'A push or a pull?' and Mrs Simon verifies that this is correct. She then goes on to pose the next question, 'What else were they [forces] needed for?' and Becky gives a correct answer, 'Stop things moving'. It is quite clear from the outset that Mrs Simon is not seeking points of view here but is focusing solely on the scientific story. Whereas in the previous episode the pupils are doing most of the talking, here the position is reversed and the pupils' contributions are limited to word fragments: 'Bouncing?', 'It pushed it'. Furthermore, whereas in the previous episode the teacher continuously *prompted* pupil responses in an open way, here she poses direct questions and *evaluates* the pupil responses. We thus see the familiar *triadic* pattern of discourse (see Mortimer and Scott, 2003) being acted out following the *initiation–response–evaluation* (Mehan, 1979) sequence:

1. **Mrs Simon:** ... what are forces? Jessica.
[INITIATION]
2. **Jessica:** A push or a pull?
[RESPONSE]
3. **Mrs Simon:** Yeah! Pushes and pulls ...
[EVALUATION]
4. **Mrs Simon:** Forces are needed to start things moving ... What else might they be used for?
[INITIATION]
5. **Becky:** Stop things moving.
[RESPONSE]
6. **Mrs Simon:** Stop things moving [nodding head]
[EVALUATION]

This I–R–E cycle continues throughout the episode and becomes even more pronounced in turns 7–18 as the teacher searches for the answer that forces can also produce a change in direction. Eventually Becky offers the desired word, 'direction', in turn 18. Finally, in turn 19, Mrs Simon confirms this correct response, reviews progress from last week's lesson and outlines what is to happen next, stressing the key scientific idea of forces acting to start, stop and change direction.

Thus in turns 1–18 the teacher adopts an *interactive/authoritative* communicative approach before finishing with a *non-interactive/authoritative* turn.

Discussion

Shifts in communicative approach

The analyses presented above show a series of *shifts* in communicative approach from dialogic approaches in Episodes 1–3 to an authoritative approach in Episodes 4a and 4b (Figure 2).

This pattern of shifts makes good sense in relation to the changing teaching purposes (see Mortimer and Scott, 2003) addressed in this sequence. Thus, initially the teacher is keen to explore a range of existing pupil understandings of the word 'force', firstly by listing ideas (Episode 1), then by reviewing dictionary definitions (Episode 2) and finally through exploring with the class, the everyday and scientific meanings of a range of 'force statements' (Episode 3). In moving to Episode 4, there is a clear 'turning point' in the flow of discourse as the teacher focuses authoritatively on the scientific point of view.

Shifts in approach and meaningful learning

The central point to be made here is that such shifting between dialogic and authoritative communicative approaches (and vice versa) is not simply 'happstance' (just happening to occur with

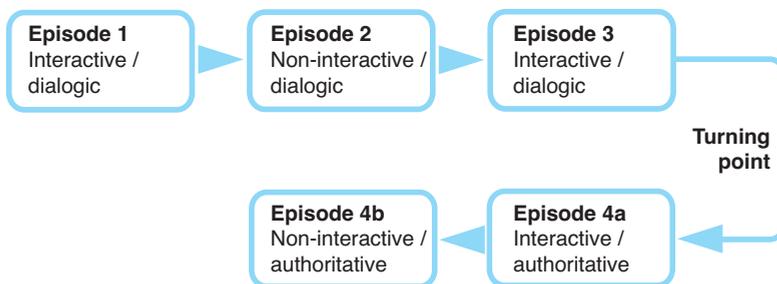


Figure 2 Shifts in communicative approach.

this teacher and this class in these lessons), but in a real and fundamental way is needed to support *meaningful* learning of scientific knowledge.

If pupils are invited to engage in dialogic exploration of ideas, then there must subsequently be authoritative approaches where the scientific point of view is isolated and clarified. This follows from the fact that science itself is an authoritative body of knowledge which involves specifically accepted ways of thinking and talking about phenomena. Conversely, if particular ideas are presented in an authoritative way, then time needs to be allowed for the dialogic exploration of those ideas. For example, once the concept of force has been established as involving pushes, pulls and changes in direction, then pupils need the opportunity to talk through and apply those ideas for themselves. In these ways authoritative talk acts as a seed for dialogic exchanges and conversely dialogic talk prompts the need for authoritative intervention.

A reasonable question to ask at this point might be: why bother with the initial dialogic approaches if the teacher is bound ultimately to introduce the authoritative scientific view? The fundamental idea here is that *meaningful* learning involves making *connections* between ways of thinking and talking so that the learner sees how any new ideas fit with existing understandings. Thus the dialogic approaches of the first three episodes provide the opportunity for pupils to express their existing views about forces, and then later, in Episode 4, to see how these views relate to the science perspective. As well as providing a first step to supporting meaningful learning, our experience is that dialogic engagement is potentially *motivating* for pupils, drawing them into the problem at hand. For example, in Episodes 1 and 3, the pupils were fully involved to the extent that Mrs Simon actually struggled to bring the discussions to a close.

The challenge for the teacher

The kind of science teaching sketched out above, and exemplified through Mrs Simon's lessons, is not particularly common. In secondary school science lessons, in particular, there tends to be far more authoritative presentation than dialogic consideration of ideas, and very often the dialogic approaches are missing altogether. Why should this be?

One reason concerns the kind of knowledge that the teacher needs to engage in dialogic approaches with pupils. Here, it is not just a question of knowing and understanding some science, but the teacher also needs to have insights into the kinds of everyday ways of talking that pupils are likely to bring to their

lesson and, crucially, to know how to respond to those everyday ideas. For example, in a later episode of the teaching sequence on forces, Mrs Simon invited a discussion of whether or not a table pushes up on a book placed on it. The class unanimously argued that the table '*cannot push up*', '*it's just in the way*', '*how can a table do any pushing – it's not alive!*' The critical teaching question is: what to do next? Mrs Simon was able to recognise this very common everyday view (of surfaces not exerting forces), to challenge it and to introduce the science perspective. This kind of teaching activity constitutes a highly skilled performance, indicative of a high level of insight and expertise.

However, this kind of teaching approach does not simply rely on using different kinds of knowledge. There is also the 'know-how' of being able to engage pupils in dialogic interactions (see Alexander, 2004), recognising how they differ from authoritative interactions. In practice, it is very easy to confuse dialogic teaching with interactive/authoritative approaches. Thus the teacher may engage pupils in lots of turn-taking which is authoritative in nature as the teacher focuses attention on the scientific point of view, ignoring contributions from pupils that are not consistent with that view. This is not dialogic interaction. One way to address this confusion is by making the link, outlined earlier, between communicative approach and patterns of discourse. Teachers, once provided with the theoretical tools, are quick to see the links between an authoritative communicative approach and the I–R–E pattern of discourse and to recognise the difference from dialogic approaches based on prompting pupils to elaborate upon their ideas. The crucial first step is to provide the tools that allow teachers to reflect upon and then to modify their classroom practices.

A further point of concern for teachers, which is likely to militate against them using dialogic approaches in the classroom, is the question of *time*. A common, and understandable point of view, is that the teacher cannot afford to spend lots of time in listening to what their *pupils* have to say. The key to dealing with this issue is to identify those parts of the curriculum where dialogic discourse becomes important, simply because the subject matter is demanding. The fact is that some parts of the science curriculum make bigger 'learning demands' (Leach and Scott, 2002) than others and it is in the areas of big demand where time needs to be spent in comparing and contrasting points of view. Thus the example given earlier of Mrs Simon dealing with the 'book on the table' problem is one that needs to be addressed through a combination of

dialogic and authoritative approaches. There will be other situations where differences between existing and scientific views are small (teaching the concept of 'speed' springs to mind here) and the science appears to be 'just common-sense' to the pupils. In such cases, it would literally be a waste of time to commit lengthy parts of a teaching sequence to

detailed dialogic interaction. The general point here is that teaching decisions to 'open-up' or 'close-down' instruction in a dialogic or authoritative way must relate to the content matter being taught, and in particular to the degree of difference between everyday and scientific views.

Acknowledgement

We are grateful for the careful work of Roslinawati Binti Mohd Roslan in transcribing the videotape for these lessons. Thanks Lynn!

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