Classroom talk and questioning in science

**Why is the issue important?**
Research (such as Alexander, 2008\(^1\)) shows that many teachers (both primary and secondary) are unaware of how to ensure their classroom talk is constructive for learning science. This research helps on both fronts.

**What did the study find out?**
The researchers found that science teachers needed to question their pupils effectively to enable them to move from their existing everyday understanding of natural phenomena towards a scientific view. These included ‘dialogic episodes’ when teachers probed pupils’ everyday ideas with further questioning and ‘authoritative’ episodes when the teacher introduced scientific ideas. Sometimes the talk was interactive and sometimes it was not. The skill lay in making the right choices at the right time. The study also showed that while primary school teachers worked at the limit of their subject knowledge, they were more likely than secondary science teachers to focus on probing with further questions due to the wider remit they had for pupils’ learning, which included ‘speaking and listening’ as well as science.

**What links between classroom talk and learning did the researchers find?**
The researchers identified the links between dialogic teaching and meaningful learning by examining the ‘pathways’ followed by individual pupils in their learning. For example, one pupil progressed from everyday to scientific thinking through a number of learning steps that included:
- becoming aware of her everyday views;
- comparing everyday and scientific views;
- developing an understanding of the scientific view;
- applying the science view in different contexts; and
- reviewing learning.

The teacher enabled meaningful learning of the science concept in question by supporting these steps in learning through activities that were mediated by talk.

**What does dialogic teaching involve?** The researchers drew on Robin Alexander’s work on dialogic teaching. Alexander found that teachers whose pupils achieved the best learning outcomes regularly used dialogue to:
- find out what the children already knew
- support and guide the children’s activity
- monitor their engagement with the progress of a topic
- assess the development of their understanding; and
- encourage more active and extended pupil talk on the part of the pupils.

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In short, such teachers made good judgements about what kind of interaction and talk was best suited for the occasion.

Alexander suggested that with dialogic teaching:

- teachers' questions are structured in ways that provoke thoughtful answers
- pupils' answers provoke further questions and are seen as the building blocks of further dialogue rather than the end point; and
- teacher-pupil and pupil-pupil exchanges are chained into coherent lines of enquiry rather than left hanging or unconnected

Typically, the teacher asks pupils for their points of view and explicitly takes account of them. For example, the teacher:

- asks for further details ('Oh, that's interesting, what do you mean by...')
- writes them down for further consideration ('Let's just put that down on the board, so that we don't forget it...'); and
- asks other pupils whether they agree with the ideas or not ('Do you go along with what Julia has just said...?').

By seeking and comparing different points of view, a teacher both enables those views to be shared and helps children to see how to use language to compare, debate and perhaps reconcile different perspectives. Teacher questions that require only brief, factual answers do not give children such opportunities. But dialogic teaching, with its emphasis on extended explanations and discussions of problems or topics, does. Alexander's comparative, cross-cultural research revealed that such extended question and answer sessions were rare the world over.

**How did the researchers characterise the kind of talk teachers used in science?**

In science, meaningful learning entails movement from the existing everyday ideas children have towards a scientific view. The researchers set out to identify strategies science teachers used to engage pupils in constructive dialogues that shifted the pupils' understanding of natural phenomena from everyday to scientific explanations. In so doing, they revealed new insights into how science teachers in particular used dialogue to support pupil learning effectively.

The researchers built on the earlier research of Mortimer and Scott which highlighted the problems pupils often have in moving between everyday and scientific understandings of natural phenomena. They showed how dialogue with a teacher may be one means of enabling pupils to take on a scientific perspective of natural phenomena. These researchers identified two dimensions of teacher-led talk:

- interactive non-interactive (which represented the extent to which the pupils were actively involved in the dialogue); and
authoritative dialogic (which represented the extent to which the teacher was positioned as the expert and the extent to which they offered possibilities for substantial contributions by pupils).

Taken together, these two dimensions allowed any episode of classroom dialogue to be defined as being interactive or non-interactive on the one hand, and dialogic or authoritative on the other. The researchers thus identified four classes of teacher-led talk in science:

- interactive/dialogic (teacher and pupils consider a range of ideas)
- interactive/authoritative (teacher focuses on one specific point of view and leads students through a question and answer routine with the aim of establishing and consolidating that point of view)
- non-interactive/dialogic (teacher reviews different points of view); and
- non-interactive/authoritative (teacher presents a specific point of view).

For example, in an interactive/dialogic episode a teacher might ask pupils for their ideas on a topic. The teacher might record those ideas on the board for future reference, or ask other pupils whether or not they agreed with what had been said. The teacher might ask pupils to elaborate on their ideas ("Oh, that's interesting, what do you mean by that?"). But the teacher would not make evaluations of these ideas, in terms of their correctness, or lead the discussion along a narrow, pre-defined track. In a non-interactive/dialogic episode, the teacher might draw pupils' attention to their differing viewpoints. With interactive/authoritative classroom talk, the teacher would act more explicitly as an expert, keep to a given agenda and direct the topic of the discussion clearly along certain routes (which may reflect the structure and content of the curriculum topic being dealt with). In a non-interactive/authoritative episode the teacher would typically present ideas in a lecturing style.

The researchers emphasised that these different types of talk did not represent better or worse teaching strategies in any absolute sense, but that teaching quality depends on making the right strategic choices between them, and that different types of talk can be complementary to each other. They pointed out that classroom talk need not always be dialogic; that there will be occasions when the teacher may quite justifiably not be interested in exploring pupils' ideas and taking account of them. The teacher may feel the time is right to focus on scientific content, to introduce some new question or concept, or to redirect pupils' attention to the phenomena under investigation. The key lies in the teacher's skilful application of a varied repertoire of ways of using language as a tool for teaching and learning.

What did dialogic teaching in science look like in practice?
The researchers provided examples of classroom dialogue they had recorded and they highlighted some of the features of dialogic talk that the examples demonstrated. The examples in this section were recorded in a primary school with a Year 6 group. The first dialogue took place during a plenary that followed a group-based activity in which the children had discussed a set of statements about the solar system before deciding if they were true or false. The second dialogue came from later in the same session. At this point,
the teacher had a large photo of the moon on the interactive whiteboard. She also had a lamp on the table (representing the sun) a globe (the Earth) and a tennis ball (the moon).

Example 1

The excerpt of dialogue below reveals a number of dialogic features. The teacher’s questions were designed to provoke thoughtful answers and encourage the pupils to state their points of view. The pupils had the opportunity to try to express their ideas clearly and hear each other’s viewpoints. The talk was interactive/dialogic because the teacher engaged in a series of questions that enabled the children to express their own ideas and did not critically assess them as right or wrong. Rather she took account of them and allowed the dialogue to continue. In this way, the teacher learned about the children's current understanding of the topic and was later able to use the information. The pupils were used to the approach the teacher used to ensure as many pupils felt able to give their views as possible - that is not commenting on whether an answer was right or wrong and asking the pupils to suggest who they would like to contribute to the discussion.

Teacher: Keighley, would you read out number nine for us?
Keighley: (reads) The moon changes shape because it is in the shadow of the Earth.
Teacher: Right, now what does your group think about that?
Keighley: True.
Teacher: What, why do you think that?
Keighley: Hm, because it’s when Earth is dark then, hm, not quite sure but we think it was true.
Teacher: Right, people with hands up. (To Keighley) Who would you want to contribute?
Keighley: Um, Sadie?
Sadie: I think it's false because when the sun moves round the Earth, it shines on the moon which projects down to the Earth.
Teacher: (to Sadie) Do you want to choose somebody else? That sounds good.

Example 2

In the sequence below, the talk had a different pattern. The teacher's talk took up a much greater proportion of the dialogue. She used the longer turns to explain (with the use of the models of the Earth, sun and moon) how the solar system generates the moon's phases. She again interacted with the children, but this time her questions were mainly used to check the children were following her explanation. The dialogue was thus interactive/authoritative, though also non-interactive/authoritative in parts. The researchers felt that the pupils' rapt attention was enhanced by their earlier opportunities to talk about the moon in their groups and in the previous interactive/dialogic episode.

Teacher: Right look, if the sun's shining from here there is nothing between the sun and the moon, so from here on Earth what we can see is a circle, a big shiny full moon. (She held the 'moon' so it was the third object inline with the 'sun' and 'Earth') Right? That's a full moon; we can see the whole caboodle, if we're here on Earth and the suns over there. However, have a look now, what happens now. If I put the moon here (she put the 'moon' between the 'sun' and the 'Earth') here's the sun, is there any light from the sun falling on this moon
that we would be able to see from Earth?
Children: No.
Teacher: What would we see if the moon is in that position?
Children: Nothing.
Teacher: Yeah, it's dark, yeah, the light needs to land on it for us, it can't shine on itself. So that's when it's the darkest bit of the moon, we can't see it (the teacher returned the 'moon' to the first position). That's a full moon, over here relative to the Earth, (moves 'moon' to second position) and that's when it's dark. However (a child tries to interrupt) wait a minute, let's get this right. If we come half way around (she repositioned the objects so that the 'moon' and the 'Earth' were next to each other, facing the 'sun') the sun's shining on this bit, but not on this bit, what would we see then?
Children: Half/half-moon.
Teacher: It would look like that. (The teacher pointed at a picture of a half moon on the whiteboard)

What links between dialogic teaching and meaningful learning did the researchers find?
To find out the links between dialogic teaching and learning, the researchers developed detailed records of the learning journeys of targeted pupils. The pupils' pathways were developed from a range of sources including what pupils said in class, written work, sketches and drawings and how they engaged in activities. For example, they charted Josie's (a Year 7 pupil) learning pathway about the normal force (which Josie's teacher referred to as the 'up-push').

Josie's learning pathway Josie's learning pathway led from an everyday view through to the correct application of normal force in different contexts. It was clear that specific teaching activities, and especially the talk around them, enabled her to take steps in meaningful learning.

The starting point was a picture (a 'concept cartoon') that depicted four points of view about what forces might be acting on a bottle standing on a shelf:
- The bottle is not moving. There are no forces on it
- The only force on the bottle is the force of gravity pulling it downwards.
- There are two forces on the bottle - the force of gravity and the push of the shelf upwards, which balances it.
- A shelf cannot push. It is just in the way of the bottle and stops it falling.

The (Year 7) class was expected to discuss the points of view presented in the concept cartoon in pairs before contributing to a whole-class discussion.

When discussing the picture of the bottle on the shelf with her partner, Josie stated that "the only force acting is gravity" and that "the shelf cannot push". This was in disagreement with her partner who maintained that "there are two forces on the bottle - the force of gravity and the push of the shelf upwards which balances it". In a plenary, Josie articulated her view to the class, "Well like, I don't think that a table can push. Cos gravity pulls, it's a force...but a table can't push upwards, it's just in the way of the erm...that's all".

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In the next lesson, the teacher referred back to the debate about the bottle on the shelf and asked Josie "What were you arguing about?" Josie replied, "That a table can't push up". The teacher used this as a starting point for arguing, with the help of a balloon, that a table can provide an upward force. After the demonstration with the balloon, Josie worked with her partner on an activity where they were asked to write down a useful way of thinking about a 'bottle on a shelf'. Josie wrote: 'The table has up-push normal force. Gravity is pulling it down. The table is pushing upwards. The bottle is pushing downwards'.

In the third lesson the teacher represented forces with arrows on a whiteboard. Josie and her partner worked on an example which showed tomatoes in the pan of a weighing scale. In answer to the question 'What are the forces acting on the tomatoes?' they showed one arrow acting down which they labelled 'gravity' and one arrow acting up which they (incorrectly) labelled 'tension'. In the plenary following this group activity, Josie contributed to placing the force arrows on the whiteboard. She correctly placed the upward and downward arrows.

At the end of the series of lessons, Josie was involved in an activity in which she had to give a 'clue' to enable a fellow pupil to guess the term 'up-push/normal force'. Josie stated, "Like a bottle standing on a shelf has gravity on it and something keeping it up from the table".

In summary, Josie progressed from everyday to scientific thinking through a number of learning steps that included:
- becoming aware of her everyday views
- comparing everyday and scientific view
- developing an understanding of the scientific view
- applying the science view in different contexts; and
- reviewing learning.

The teacher enabled meaningful learning of the science concept in question by supporting these steps in learning through activities that were mediated by talk.

How was the research designed to be trustworthy?
The research was carried out in five primary schools and three secondary schools and involved six primary and six secondary teachers and their Year 5/6/7 classes. The researchers made recordings of the teachers’ talk as they interacted with whole class, small groups and individual pupils, and the talk that occurred amongst a group of pupils in each class. From this they identified approaches and patterns of interaction. The researchers also interviewed a sample of pupils in each class immediately after lessons and several weeks later, and gathered written work to elicit their understanding of the science concepts taught. Approximately 120 hours of classroom talk and 20 hours of interviews were recorded.

What are the implications?
The research showed the importance of teachers:
- examining and reflecting on their own dialogic teaching skills including probing and further questioning, and analysing example dialogues to increase their awareness of how they use talk and how talk can be used;

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• planning activities designed to make pupils’ everyday assumptions explicit (such as sets of statements to talk about that include common misconceptions);
• noting down pupils’ everyday assumptions to use in future lessons when demonstrating the scientific view; and
• monitoring, together with pupils, the development of pupils’ understanding of scientific concepts.
• Could you explore how often and confidently you use these strategies with a partner?

It also showed the importance of school leaders:
• bringing primary and secondary teachers together to enable primary teachers to develop their scientific knowledge and secondary teachers to develop their use of further questioning in science classrooms; and
• encouraging science teachers to analyse example dialogues from science lessons perhaps using the key elements of dialogic teaching in science identified by the researchers as a framework.
• What opportunities exist for following up these strategies?

Case studies

Using puppets to promote talk in primary science
We chose this case study because it shows how teachers were helped to change the way they used talk in science lessons. It built on previous research which showed that many primary teachers do not maximise children’s talk due to uncertainty over the value of children’s conversations, limited knowledge of appropriate teaching strategies and insecure subject knowledge. The approach to professional development was innovative. The 16 primary teachers who took part were introduced to the idea of using puppets in science lessons.

How did the teachers use the puppets?
The teachers first attended a workshop where they were given guidance on how puppets might be used effectively. All the teachers appeared to settle on an arrangement in which they used puppets near the start of the lesson to present problems and plausible alternative ideas to the children and to create an air of uncertainty that the children cared about resolving. For example, one Year 6 teacher used puppets to set up a scenario where one puppet (Liam) disagreed with another puppet (Ruby). The context of the lesson was about how a streamlined shape could enable penguins to move more easily in the water. Liam thought the shape of the penguin had nothing to do with how it could move in the water;


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Ruby thought it did and she suggested a practical method to show that the shape did have an effect on the speed at which shapes move through water. This helped the children to engage with ideas that are in tension with each other. The puppet character, and the story it told, also made the problem an authentic problem which the children were keen to solve in order to help the puppet.

The puppet was viewed as a peer by the children (without the status and authority of the teacher) and this enabled the teacher to present ideas through the puppet that the children would not readily accept from the teacher, including ideas that were wrong. This led the children to view the puppet as the least knowledgeable member of the class. For example, a Year 3 teacher’s class was investigating how the position of the sun appears to change in the day. Making the puppet’s shadow shorter, the puppet told the children someone must have washed it to make it shrink! The teacher felt that if he had said this the children would have realised that he was leading them on. The puppet also suspended judgement about the children’s ideas, which encouraged them to justify their ideas in order to convince the puppet.

The teachers also used the puppets at the end of their lessons to explore with the children what new learning had taken place. The most successful use of the puppets was when the teacher introduced the puppet slowly to the class and developed a strong sense of identity for it – a peer who knew less than the children. Some teachers took care to retain the puppet’s character even when it wasn’t being used, such as giving it a seat to sit and watch the children at work. It was important that the puppets talked directly to the children; puppets that listened to the children and whispered to the teacher did not appear to work so well.

**How did using the puppets affect the teachers’ talk?**

There was a difference in the teacher’s questions when they used puppets. When video recordings of lessons taught by the teachers (with and without the use of puppets) were analysed (according to a coding framework) the data showed an increase in the teachers’ use of reasoning questions and a decrease in their use of non-reasoning questions in the puppets’ questions. The teachers’ increased questioning style created more opportunities for thinking in the puppet lessons. By presenting problems through puppets, it appeared that teachers were less likely to retain their previous didactic teaching style based on questions testing pupils’ recall and were more likely to ask more open reasoning questions. There was a corresponding increase in the children’s use of argumentation and a decrease in their use of recall responses in the puppet lessons. Consequently, there were more opportunities for children to develop their thinking about science in the puppet lessons. These changes were evident both where the teacher had already built up a high level of opportunity for reasoning and argument before using puppets, and where the teachers had previously provided little opportunity for reasoning and argument.

**What effect did using the puppets in science lessons have on pupils’ talk?**

Analysis of recordings of pupil talk in small groups revealed an increase in the amount of talk the children used that involved reasoning and a decrease in the amount they talked about practical and procedural matters in the puppet lessons. As the total amount of time spent in
small group conversations was broadly similar in lessons with and without the puppets, the
increase in the amount of talk involving reasoning represented a change in the nature of the
children’s talk, not an increase in the amount of time made available by the teacher for
talking in groups. The puppet had presented a problem in a way that created uncertainty,
and resolving the uncertainty became the focus of the lesson. The puppets thus created an
obvious purpose for their scientific activities. Teacher intervention in the small group
discussions was minimal; the main responsibility for solving the problem became the
children’s. A teacher commented:

‘[The children] seemed to know what they were doing … They showed me that we
often do intervene too early and do not give children enough time to work through a
problem themselves’.

The children were also more engaged in the whole-class interactive sessions when puppets
were involved. The teachers noticed that their classes became more animated; the children
wanted to talk to the puppet and hear what the puppet had to say. They talked to the
puppet as if it was a separate person to the teacher. Although they knew it was the teacher
talking, they talked to the puppet like it was a new friend or another pupil in the class who
knew less than they did. Consequently, they worked harder than usual to explain their ideas
to the puppet (who didn’t understand) than to the teacher (who ‘knows all the answers and
will know what they mean even if they don’t explain it well’).

Several teachers noted how the puppets were particularly effective with shy children. They
noticed how children who were usually reluctant to talk began to take a more proactive role
and were more willing to respond to the puppets or engage in dialogue with the puppets.
The children explained why they felt more willing to talk:

‘I’m not nervous talking in front of the class [with the puppet] … because they all
look at the puppet not me’.

‘The teacher already knows the answer anyway. So she’s really just testing you. The
puppet doesn’t know the answer so we have to explain it in a way he will
understand’.

What did the researchers conclude about the value of the approach for teachers’ CPD?
The researchers highlighted how research on teacher change is consistent in suggesting that
teachers can find it hard to change their practice, particularly with regard to their use of talk.
But this project showed how using puppets prompted substantial change in teachers’ talk
over a relatively short period of time and after only a short preparation session. The puppets
helped by changing the teacher’s role from expert to co-learner because the puppets were
introduced as peers who talked like the children and required simple explanations of
scientific phenomena. The researchers felt that other teachers would welcome the approach
to professional development as it did not require a large investment in terms of time, energy
or resources to introduce the project – the project teachers simply incorporated the puppets
into their usual science curriculum.

Reference
The PUPPETS talking science project: www.puppetsproject.com/index.php
Examining different kinds of talk patterns in science

We chose this case study because it showed how a teacher alternated between two kinds of talk: direct questioning centred on pupils’ understanding of science content and discussion centred on pupils’ sense making. Analysis of these different kinds of talk revealed the different messages that talk sent to the pupils. The direct questioning positioned the teacher as expert, while the more extended discussions between pupils and between the teacher and pupils positioned the teacher and the pupils as co-learners.

The study involved a teacher in his second year of teaching and his class of 29 fourth-grade pupils (aged 9-10 years) at an elementary school in Manhattan. A teacher on a Masters programme mentored the teacher and collected the data. A number of science lessons were video-recorded. During class discussions, the camera was placed in a corner facing the teacher and pupils; while the pupils were doing group work, the mentor took the camera round to different groups. The mentor also encouraged the pupils to talk about their ideas, questions and feelings on classroom talk and science during interviews with them.

Direct questioning focused on pupils’ understanding of science content

Direct questioning generally took place during whole-class question and answer sessions. With the use of props, such as a light switch or a diagram on the board, the teacher posed a question and called on individual pupils or the whole class to reply, as in this example:

Teacher: (referring to a diagram of a circuit on the board) What can I put in to turn the light bulb on and off? Amy?

Amy: A switch.

Teacher: A switch. Excellent Amy! Where do you think I can put the switch? Can you put the switch in for me? Draw a box where you want. Amy walked to the board and drew a switch close to the battery.

If the response was correct, the teacher praised the pupil, repeated the answer or posed another question. The teacher usually provided an explanation as to how or why the answer was appropriate. But if the answer was incorrect, the teacher asked the pupil to reconsider his/her answer and explained why the answer was incorrect or different to the one he was proposing.

Reflecting on the whole-class talk pattern, the teacher commented:

‘We do have whole class conversations... I think it’s a little overwhelming for me to have a conversation with thirty kids and to try to remember where Janna was or where Tanya was ... So the whole class conversations are directed, very directed almost fishing for an answer which is not necessarily the best way to teach, but that’s where I’m at right now’.

Discussion focused on pupils’ sense making

After the whole class discussion the pupils worked in groups or with a partner on a challenge presented to them by the teacher (called ‘project time’) such as creating a switch. During project time, the pupils discussed their understandings, questions and ideas about the
project. They talked about their observations, gave demonstrations to one another and provided one another with explanations. Pupils were encouraged to walk around the classroom and hold discussions with other groups. For example, when the pupils were asked to make switches (having been given batteries, wires and paperclips), one group of pupils managed to get their switch to work by placing the two paperclips together. Pupils from other groups gathered round them to watch. Another group made their switch by having the top wire pressed down on the bottom one and called out to their teacher to tell him how they had made a different one.

During project time, the teacher also walked around the classroom talking with the pupils about their plans, accomplishments and discoveries. He asked the pupils questions about their circuit (how and why it worked in that particular way), listened to their explanations, and encouraged pupils to work together. The teacher also made it clear to pupils his expectations of pupil collaboration: that the process of doing work together involved dialogue with another pupil and that the point was to learn things from and with the other person.

Analysis of the messages the talk sent to the pupils

The mentor’s analysis highlighted the following points regarding direct questioning.

- Direct questioning, whereby the teacher asked closed questions that often had only one correct answer (for example, the teacher turned off the light and asked the pupils “is the circuit open or closed?”) sent the message that science learning involved providing the right answers to the teacher. It also sent the message to pupils that science involves knowing particular facts and vocabulary.
- It was assumed that the teacher knew the answers because he provided praise when pupils gave the correct response.
- Since the talk focused on pupils providing the correct response and pupils often give incorrect answers, pupils may gain the impression that science is a difficult subject.
- During the discussion, the teacher usually explained the answers or the reasoning. Because the teacher took on the sole responsibility of confirming the scientific knowledge, he was viewed by the pupils as the only expert.

The mentor’s analysis highlighted the following points regarding the talk during project time.

- Expecting pupils to explain how and why things worked in their view suggested that science involved having reasons as opposed to the idea that science is just facts and knowledge to be learned or memorised.
- Through having conversations with other pupils about their understanding of the material, pupils may come to understand that science involves more than just making observations or giving answers. The conversations also mean that the authority of science or science knowledge is not solely placed on the teacher – pupils can approach one another for help. For example, when one pupil was unable to make her switch work, her friend suggested that the paperclip needed to touch both the other paperclip and the wire.
- Challenges/obstacles the pupils encountered during project time, such as a dead battery, broken light bulb or unattached wires that prevented their circuits from working allowed the pupils to see the importance of problem solving in science.

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• Allowing the pupils to approach the problem (such as making switches) in different ways conveyed to pupils that science allowed for different solutions or creations and that each was acceptable. It also suggested that the process of doing science was not always formulaic. Rather, the practice of science involved trial and error as well as finding solutions. Science was more than just drawing diagrams, for as the pupils tried to create their circuits, they began to realize that doing science involved adjusting their plans or finding a solution.

The mentor concluded that as different patterns of talk send different messages about what science means, how we do science, what science is and who does science, teachers should consider what they want pupils to know about science when thinking about the kind of talk they propose to use. She also felt that it was important for leaders to learn about where teachers are in the process of learning how to conduct a discussion in science. She felt that teachers should be given the support they need to build their teaching skills and be provided with opportunities to practice how they might talk in the classroom.

Reference

Analysing classroom talk in science
We chose this case study because it provides examples of longer dialogues and more detailed analysis of them than is possible in the main study. The episodes occurred during a series of Year 7 science lessons (pupils aged 12 years). The teacher was a science specialist with about 20 years teaching experience. The class consisted of pupils of a full range of abilities.

Episode 1
At the start of the first lesson, the pupils were asked to discuss a concept cartoon entitled ‘Bottle on a shelf’. It portrayed four points of view about what forces might be acting on a bottle placed on a shelf:

- The bottle is not moving. There are no forces on it. (A)
- The only force on the bottle is the force of gravity pulling it downwards. (B)
- There are two forces on the bottle – the force of gravity and the push of the shelf upwards, which balances it. (C)
- A shelf cannot push. It is just in the way of the bottle and stops it falling. (D)

The pupils first talked in pairs about each of these statements indicating whether they ‘agreed’ or ‘disagreed’ or were ‘not sure’ about each one. Each pair of pupils then worked with another pair to compare views and to reach a consensus within the group of four. Finally, the teacher called the class around the table at the front of the room for a whole class discussion. The concept cartoon ‘Bottle on a shelf’ was projected onto the white board. An excerpt from the ‘round table’ discussion is given below.
Teacher: Now I tell you what if I was in one of your groups I’d have found that pretty confusing because of the number of different ideas... Now I was over there with Josie and with Ryan and with Jordan and Kerry. Now they were looking at this and I tell you what...they really didn’t agree at all. There was a fundamental – that means a really important – disagreement. So I’m going to ask them if they can lead off for us and just have a look at some of the ideas they talked about...

Josie: Well like, I don’t think that a table can push. Cos gravity pulls, it’s a force...but a table can’t push upwards, it’s just in the way of the erm...that’s all.

Teacher: Right. Let’s have a listen to what she’s saying there. She’s talked about the force that a lot of you have talked about, gravity. She’s told us where she thinks that is, and what she thinks that’s doing. But the disagreement between the two of them is whether the table can do anything. Now I think when I was listening to Ryan that he was here [points to cartoon statement C]. That there are two forces on the bottle the force of gravity and the push of the shelf up which balances it, and I know ‘balance’ is a word that a few of you were using. And I think that Josie is here [points to cartoon statement D] a shelf cannot push it is just in the way of the bottle and it stops it falling. Now let’s use that as a starting point...

The concept cartoon prompted active consideration of different points of view by the pupils, thus drawing them into the problem. If the teacher had simply asserted in a non-interactive/authoritative way that ‘the shelf pushes up on the bottle’ (expecting rote acceptance) there would have been no opportunity for the pupils to explore the differences between their ideas and no opportunity to make links to their existing ideas. Instead, the teacher made a virtue of the pupils’ different interpretations of the problem. In the plenary, the teacher first of all drew attention to the ‘fundamental disagreement’ which had developed between two of the pupils, Josie and Ryan (recognising that this disagreement entailed a key difference between everyday and scientific views). The teacher drew attention to the disagreement by adopting a non-interactive/dialogic communicative approach to review (with the help of Josie) both scientific and everyday perspectives. In doing so, he pinpointed the key issue: whether the table can do anything.

Episode 2
The teacher then asked some more pupils to give their views. The teacher encouraged contributions and five pupils offered points of view, making relatively extended comments. The teacher referred systematically to the ideas presented in the concept cartoon, but offered no evaluation of the pupils’ comments. In this way the teacher encouraged an interactive/dialogic approach in which the pupils offered a range of ideas. The following is a short excerpt.

Paige: Cos it’s like pushing it up and that’s pushing it down...[not audible]

Teacher: Yes we’ve got this idea of what would happen if it wasn’t pushing up, so you’re kind of tending towards to which one? Ryan’s sort of area there [points to view C of the cartoon]. Anybody else like to join in with this one? Zoe?

Zoe: I thinks it’s, erm, the one where there’s two forces, because there has to be something that’s holding it up that stops gravity pulling it down. So erm, the table must be pushing it up in some way.
Teacher: You’re thinking about this as logically as you can, you’re saying it couldn’t possibly be where it is if there wasn’t something going upwards?

**Episode 3**
The teacher started this episode by referring back to the previous lesson and in particular to ‘the ideas that you really argued about on Monday’. He not only referred to the argument (about the table not being able to push up) but also to the particular pupils who were involved: ‘Josie was in the middle of this and Jordan was in the middle of this argument’. Then the teacher changed to an interactive/authoritative approach by presenting the scientific view of the normal force. This shift from a dialogic to an authoritarian approach constituted a turning point in the sequence of episodes as the dialogic interactions were closed down and the teacher focused on the scientific point of view:

Teacher: What I want to do...I want to leave you this morning...is a picture of something that might help you to believe that that [knocking on the table] can push up. Now this is a very logical little argument, so you’re gonna have to follow it through.

With the help of one of the pupils, the teacher presented an argument to the class that suggested that the table can push up, by focusing attention on the forces acting on a balloon. He asked Sam to squeeze a balloon between his hands.

Teacher: Now what’s he doing to the shape of that Sharon?
Sharon: He’s making it flatter.
Teacher: Going flatter.
Teacher: Now you’re going to have to describe this, what you’re doing now. So just let go. What are you doing with this bottom hand Sam?
Sam: Sort of like pushing it [in quiet voice].
Teacher: He says he’s sort of like pushing it. But you really are pushing it, aren’t you? That hand is pushing up at the same time as that one is pushing down [teacher stands next to Sam and gestures up and down]. In doing that he’s changing the shape of the balloon isn’t he? Now if you put that balloon on the desk now. Can everybody see? Put your hand on top there now and do the same thing [Sam pushes down on the balloon on the desk]. Not too hard. What’s he done to the shape of the balloon there Sean?
Sean: Pushing it down...
Teacher: He’s pushing it down. What’s he done to the shape?
Sean: Flattened it.
Teacher: Flattened it. Now, he’s only got one hand on there at the moment. Where on Earth is the other force that’s changing the shape? Where is the other force that is changing the shape? Let’s hear a few people telling us.
Holly: From the table.

The teacher did not set about proving some pupils were right and some pupils were wrong, but set about helping them to believe in a difficult idea. At the critical point in the lesson sequence when some pupils in the class had committed themselves to arguing that the shelf cannot push up while others stated that it could, the teacher chose his words carefully:
Thus the teacher did not talk of proving some pupils right and others wrong, but of helping them to believe in a difficult idea. The success of the approach can be gauged in part by Josie, who as reported in the main study, was initially quite clear that a table cannot push up, but by the end of the sequence had accepted the scientific view. The researchers argued that though some argue that exposing pupils’ views through dialogic interaction could lead to a negative personal response if they later prove to be at odds with the scientific view, that this was not the case for Josie. Much depended on how the teacher handled this. As shown above, the teacher in this example chose his words carefully. For example, at the start of the first lesson he welcomed several pupils’ points of view without evaluating them. Later, he explained that he wasn’t setting out to prove that some pupils were right and others were wrong, but that he was helping them to believe in a difficult idea which he accomplished through carrying out an experiment. Teachers may also want to comment on how scientists work in this way – that they start with a hypothesis then carry out experiments to check its validity.

Reference
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What do the case studies illustrate?
The case studies complement and illustrate aspects of dialogic teaching in science explored by the researchers. They show how:

- a group of primary teachers changed their pattern of classroom talk quickly and easily through an innovative approach that involved using puppets;
- one teacher alternated between two kinds of talk (authoritative talk during whole-class teaching interactions and probing questioning during group work) and the messages the two kinds of talk sent to the pupils;
- a teacher’s dialogue helped pupils to move from an everyday understanding of forces to a scientific view; and
- concept cartoons (which present a picture of a recognisable situation along with different points of view) were used as a stimulus for promoting purposeful argument between small groups of pupils in science.

To read the full resource, go to:
http://www.curee.co.uk/node/4836

This resource is an extract from a RFT created by CUREE for the General Teaching Council for England.
For further practitioner friendly resources, visit www.curee.co.uk