Talk in primary science: a method to promote productive and contextualised group discourse

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Modelled Discussions About Science (MoDAS), where adults talk together about scientific ideas, procedures and applications, were devised to model and improve the quality of pupils’ discussions. Two examples from one of the project schools are examined to see if these aims were fulfilled and to comment on examples of cognitive and social aspects of discourse and argumentation. Successful features of adult modelled talk included the use of clearly signed ‘big-D’ discourse for example, how adults take turns, signal agreements and disagreements and challenge each other. Analysis of cognitive aspects of pupils’ talk showed sophisticated levels of argumentation. Social functions of dialogue were observed particularly with older pupils. The method is also a way of linking industry and school science so that science learning is more authentic.

Keywords: discourse; argumentation; industry and science links; primary science

Introduction

The research described here exemplifies the role educational research can play in teacher development and in illuminating pedagogy associated with collaborative group work. As the approach reported used contexts from industry, the research also provides insights on school-industry links. A new approach to help pupils enhance the quality of their group discussions in science lessons was devised. Modelled Discussions About Science (MoDAS) are a way of using adults talking together to help primary-aged pupils improve their collaborative talk by having good examples to follow and reflect on. Since the research was pragmatic, to inform a training resource, the approach had to have the potential to provide insights on the actions and content of adults’ and pupils’ discourse so that new users could see the benefits and pitfalls of using MoDAS. The research involved video recording examples of MoDAS and then looking for signs of the adults’ discourse moves and signals that might have helped pupils. The conversations of adults, and subsequently of groups of pupils, were transcribed from the recordings and then the main research issue was which method of analysis would be most useful in communicating how to use MoDAS. Below, as in the training materials, examples of adults’ and pupils’ discourse are presented with reflective commentaries so that readers and users of the

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materials can judge to what extent the aims of MoDAS and the quality of discussion and argumentation were apparent.

The MoDAS initiative is part of a larger effort to bring about pedagogical change in primary schools in the UK, the Discussions in Primary Science Project (DiPS). Talk between pupils and its role in cognitive and social learning has been the subject of study over a number of years. The seminal work in the UK of Barnes and Todd (1995), Edwards and Mercer (1987), Des-Fountain and Howe (1992) and in the US of Palinscar and Brown (1984) points to the importance of classroom talk in providing, ‘... worthwhile opportunities [for children] to work together in small groups, making meaning through talk’, (Des-Fountain and Howe 1992, 146). In science lessons pupils’ talk has particular importance for learning because:

1: Talk in science helps children to construct their understanding

Talking together improves critical thinking and helps children to think about their ideas and compare them to the ideas of others including scientists. Talk rather than writing allows children to rehearse their thinking in a collaborative and safe learning environment because, as Barnes points out: ‘the flexibility of speech makes it easier for us to try out new ways of arranging what we know’ (Barnes 1992, 125).

2: Talk in science helps children have a more realistic view of science

Science knowledge and ideas are constructed and can be challenged and changed as new evidence is produced. This is the basis of scientific endeavour through which scientists, in Neil Mercer’s words, use the: ‘process of argument ... to establish which “truths” we agree on’ (Mercer 2000, 13). In contrast, many children (and adults) think all scientists do is put on white coats and work alone in laboratories. In fact scientists collaborate and talk in communities more than they work at laboratory benches. Doing science therefore requires talking science.

3: The 21st Century requires scientifically literate citizens

Children today live in a world increasingly dependent on knowing and understanding some science. As adults their decisions will likely involve their health, their living standards, their leisure and ultimately what kind of world they want to live in. Science education in (secondary) schools is changing rapidly to reflect these needs. Since discussion and argument about evidence and issues can advance scientific thinking (Kuhn 1992) and are now increasingly advocated and practised in secondary school science (Osborne, Erduran and Simon 2004), primary children ought to be ready for the consequent changing styles of teaching and learning.

There have been previous efforts to develop talk in primary classrooms. For example, in the early 1990s the work of the National Oracy Project (NOP) in England translated theoretical considerations and research findings into practical classroom actions (see Norman 1992 for a succinct review of the NOP). More recently there have been efforts to enhance group talk in primary schools through ‘dialogic teaching’ (Alexander 2004) or by teaching to help improve pupils’ ability to talk productively in groups (Howe et al. 2007; Dawes, Mercer, and Wegerif 2000). In spite of these efforts, evidence from systematic reviews of international research (Bennett et al. 2004) shows use of group talk activities in science lessons has been at a very low level, particularly when teachers see science as about factual learning rather than including argumentation and discussion of science topics. The approach reported is part of an effort to redress this.
The Discussion in Primary Science (DiPS) project
This two-year project involved 36 primary schools in a Local Authority (LA) in the North East of England. Schools were urban or suburban and mostly took pupils from areas of severe economic and social disadvantage and with low levels of educational achievement (though this was not the case for the school in which the research reported here was carried out). The project was supported by a grant from the AstraZeneca Science Teaching Trust which supports research and Continued Professional Development (CPD) for teachers in science, mainly in the primary sector. Although the focus of the project was in science, outcomes were intended to benefit the whole curriculum. The MoDAS approach described here was part of the second year of the project in which methods and activities were extended to a larger number of schools.

Modelled discussions about science (MoDAS)

**Conceptual framework**
Theoretical foundations for designing activities, where adults talking together at the beginning of class models discourse that consequently helps learners develop their own talk in science, were:

1. Gee’s concept of ‘big D’ discourse – through which learners pick up on more than nuances of language in successful talk, i.e. from body language and signals for turn taking, challenges and so on (Gee 1999); and
2. social learning theory – identifying organisational aspects of purposeful collaborative talk in groups (Wells 1999; Wood 1998).

MoDAS provide spaces in which metadiscoursal skills (Hardman and Beverton 1993) can be developed by learners where reflection on, rather than merely copying, adult discourse plays an important part.

Systematic reviews of the literature on context-based learning in science reveal that real-world, science-technology-society (STS) contexts are attractive to and motivating for learners (Bennett, Hogarth, and Lubben 2003). The Centre for Innovation and Research in Science Education at the University of York has a history of successful school-industry work stimulating productive science lessons in primary schools. For these two reasons the DiPS team decided that adult group talk and the classroom activities that preceded or followed it should be based in contexts drawn from industry close to schools involved in the project, in this case a large chemical plant on the outskirts of the city.

**The aims of MoDAS**
We saw MoDAS improving pupils’ science talk by:

1. *Modelling productive discourse*: to demonstrate key dialogic moves and cues that help move discussion and argument in new or more productive directions (Alexander 2004; Mercer, Wegerif, and Dawes 1999).
2. *Modelling construction of meaning*: showing that adults use language and pose questions in ways that elicit and provide explanations to clarify
meanings and establish better understanding of terms, concepts, principles, procedures and theory (Scott, Mortimer, and Aguiar 2006).

(3) Modelling ‘how science works’: providing a more authentic version of science whereby learners see that ideas and theories are subject to challenge and validation through discussions between scientists rather than being accepted as pre-determined truths. This is part of a component in the English National Curriculum for science often referred to as ‘How science works’ (DfES 2004, 37–38).

The MoDAS activities

Two examples of MoDAS were developed and researched in one project school. Both drew on contexts at a local chemical plant and involved a planning meeting between adult participants prior to teaching. The first involved pupils in a Y3/4 class (ages 7–9) in discussion about choosing the right gloves to carry out tasks at the chemical plant. Concepts included the, flexibility, porosity and protective properties of materials. The second involved a Y5/6 class (ages 10–11) discussing methods for dealing with excess heat from the chemical plant and deciding which would be most suitable. Concepts included heat transfer and the economic, practical and environmental implications of heat exchange. In both cases the work was spread over two lessons. Pupils were introduced to a specific problem by an industrialist and the class teacher and then practical work was carried out. In the case of Gloves, the MoDAS activity took place at the start of the second lesson and involved the ‘adults’ – the industrialist, class teacher and another teacher – modelling discussion about glove choice for tasks at the chemical plant. In the case of the second example on Heat exchange, the main MoDAS took place in plenary class discussion and involved the class teacher, the same industrialist and the author. Figure 1 summarises the components of both lessons that relate to talk activities and specific strategies used to scaffold and support pupils’ talk.

The research

Two research questions (RQs) were identified:

**RQ1:** To what extent are the three modelling intentions of MoDAS represented in adults’ modelled talk?

**RQ2:** To what extent are social and cognitive aspects of discourse evident in adults’ modelled talk and pupils’ group talk?

Both lessons were videotaped professionally using a single camera and multiple microphones. The recording team was under the direction of an experienced researcher (the author) who took field notes during the lessons. All recordings were transcribed verbatim. The research team considered three types of analysis commonly used in research on classroom discourse:

(1) Qualitative methods: often semi-ethnographic descriptions accompanied by open reflective commentary.

(2) Quantitative methods: for example counting words, phrases or ‘key usages’ and sometimes correlating features of talk with factors such as pupils’ performance in tests.
Figure 1. Modelled Discussions About Science (MoDAS). Lesson components and strategies used to support science talk.
Mixed methods: typically using software to scan talk for ‘key usages’ and their positions or functions in the discourse.

Since we were interested primarily in describing social and cognitive outcomes and communicating a new approach to teachers and did not wish to count language use or correlate it with other factors such as pupils’ performance, we decided on the first of these. Social aspects of pupils’ discourse were identified according to the list produced by Barnes and Todd (1995, 27–8). Since most of the dynamic, cognitive aspects of group discourse turned out to be features of argumentation, Toulmin’s Argumentation Pattern (TAP), as applied by Erduran, Simon, and Osborne (2004), was used to identify and comment on the occurrence and use of claims, warrants, rebuttals and qualifiers. This application of TAP has the advantage that levels of argumentation, mainly on the basis of the occurrence of warrants and, particularly, rebuttals can be assessed. In Erduran, Simon, and Osborne’s (2004) scheme the highest levels of argumentation are those that contain warranted rebuttals to the claims, warrants or backings made by others.

Analysis of and reflection on MoDAS and pupils’ discourse
Extracts of transcribed talk are presented for both examples. In the case of Gloves the first is from the adults’ (modelled) talk and the second from discussion of one group of pupils that followed it. The selection of groups was made on the basis of audibility and practicality for training purposes rather than to be representative of all, or most, group talk that took place. In the style of Barnes and Todd (1995), the extracts below are accompanied by reflective, analytical commentaries.

The Gloves MoDAS

Extract 1: Modelled discussion (about choosing gloves)
In this extract MH is the industrialist from the local chemical works, CS is the class teacher and SG is a second teacher with responsibility for coordinating science in the school. Italicised text shows key physical (Big-D) actions noted from watching the video.

MH: The first job that I did was working in a laboratory. Now I was going to ask what kind of gloves do you think I would wear whenever I was in a laboratory?. ‘cos the first thing I wanted to do was to protect my hands but I also needed to be sure I could do the things I needed to do. (At this point SG places a ‘puppet’ on her left hand and CS takes a yellow glove with green finger grips)

CS: (Turning to face MH and holding up the glove) Well, I think these gloves are really good because they’ve got a good grip to them. (SG’s puppet takes a yellow rubber (marigold) glove in ‘his’ hand) I think if you were holding things in the laboratory you would have to make sure you didn’t drop things if you are holding dangerous chemicals. I think these gloves might be really useful . . .

MH: (Looking at CS) Well, they would be . . . for some things we would do in the laboratory they would be useful, however, (taking the glove offered by CS) there is one difficulty with these gloves. (MH puts one of the gloves on his right hand) If I had to put my hand inside one of these . . . and then
if I had to work with a liquid like water (*MH tries to ‘wiggle’ the fingers of his gloved right hand*) and I had to put my hands inside ... the water would go straight through (*MH turns the gloved hand over*) so they wouldn’t keep my hands dry.

**SG:** *(Speaking through the puppet who holds a yellow rubber, ‘marigold’-type, glove in ‘his’ left hand)* So, these would be OK wouldn’t they?

**MH:** Actually they would ... actually ... they would be much better ... here, can I borrow these ... (*HM reaches across to SG to take the yellow rubber glove from the puppet’s hand*)

**SG:** *(Not ‘through’ the puppet)* They’re flexible ...  

**MH:** These ones are flexible ... (*MH puts the yellow rubber glove on*) and the great thing about these gloves (*MH stretches them to fit*) is that if you were to splash chemicals on your hand ... this would keep the chemicals away from your skin ... so keep your skin safe and protected ... so these are really useful gloves. *(SG’s puppet selects another type of glove made of grey coloured suede leather)*

These aren’t perfect for every job though and sometimes whenever you are doing things ... with very hot things and you would have to use a very different type of glove.

**SG:** *(Apparently speaking through the puppet who has an example of the suede glove in ‘his’ mouth)* So what about these? They are nice and chewy. They are big and strong ... look. *(SG tugs at the glove held by the puppet’s mouth)*

**MH:** They are very strong ... and a bit like what we call gauntlets ...
lessons, are much more likely to do so when invited to speak by a puppet. In this case the use of the puppet was confusing and a distraction to the MoDAS. For example, towards the end of the MoDAS, the ‘puppet’ grabbed an example of a glove in his/her mouth ‘claiming’ that the glove is, ‘... nice and chewy’, not a property of gloves that has anything to do with protection against liquid chemicals or that was the focus of previous exchanges.

Extract 2: An example of pupils’ group discourse following the Gloves MoDAS
This is the transcribed talk (where audible) of a group of five pupils, three girls and two boys, invited by MH to discuss which gloves would be best to wear in the kitchen. Comments, related to TAP, have been added (in bold italicised text) after some pupils’ utterances.

Girl 1: (Reaching to take a pair of gloves from the pile on the desk) These look good.
Girl 2: Yeah ... they’re stretchy ... big ... (indistinct).
Girl 3: I think them ones (taking green and yellow gloves with rubberised palms) ... ‘cos you can pick up sharp bits.

(TAP) Warranted claim.

Boy 1: (Reaching to pick a pair of yellow rubber gloves) Yeah but these rubber gloves ... . (indistinct) ...

(TAP) Possible example of counter claim or weak rebuttal.

Girl 3: (Trying on a different pair of yellow and blue cloth gloves) Yeah ’cos a pencil’s sharp.

(TAP) Backing her earlier warranted claim.

Boy 1: You could wear that (glove) and ... then wear that (i.e. he means wear a large silver gauntlet over the top of the blue-yellow glove).

(TAP) Qualifying his earlier choice.

Girl 3: But how could ya ... go on ... put it on then (Boy 1 tries on the silver gauntlet but not over the other glove).

(TAP) Challenging – asking for additional information (social discourse).

Girl 3: (Reaching over to take one of the yellow rubber gloves from boy 1) They’re alright for washing up ... . These (the yellow and blue gloves again) are ... (indistinct) ... for grip ... if you drop a plate.

(TAP) Third warrant for her choice, backed by an example.

Boy 1: (Chooses a green coloured rubber glove) ... (recording ends).
Commentary
In terms of TAP, there was evidence of quite sophisticated argument here, a
challenge to those who believe that pupils of this age (7–9) rarely do this. For
example, Girl 3 provides three warrants for her selection of glove, the last of which is
backed by an example, ‘for grip . . . if you drop a plate’. Although this extract shows
only three of five pupils in the group contributing to discussion, there was evidence
on the video recording that participants took turns, listened to each other and
reasoned their choices. When the recording was played back to the class teacher
(CS), she was impressed with the levels of talk used by these pupils.

The Heat Exchange MoDAS
In this case the modelled discussion took place towards the end of the lesson as a plenary
class discussion (see Figure 1). This was not part of the original planning but occurred
because discussion was a natural consequence of the sequence of events that preceded it.
The group discussions that occurred immediately before the MoDAS had different foci
(as shown in Figure 1). The first concentrated on findings from experiments to cool hot
water that each group carried out. The second considered results from these experiments
and discussion focussed on which method tested by pupils might be best (most practical,
economic, efficient) to use to cool water at the chemical plant. There was some modelling,
by way of feedback to pupils given by the industrialist (MH) on how effective the first
discussions had been, before the second discussion took place. The extract below is from
this second round of group discussions.

Extract: An example of pupils’ group discourse that preceded the MoDAS
The group comprised two boys and two girls. As before, argumentation features
according to TAP are shown where relevant. The ‘granny method’, referred to by
some of the pupils, involved pouring hot water into a container of larger surface area
to cool it, therefore like a ‘Granny’ (Grandmother) might cool hot tea by pouring it
from a teacup into a saucer before drinking.

Boy 1: But also the wind one (using the natural availability of wind or electric
fans) would be quite good because you’re not just using one method
(the ‘granny’ method), you’re using two, so it gets it done quicker and
you’re also getting it done, it’s cheap.

(TAP) warranted and backed claim.

Girl 1: Yeah, but what if it’s not windy enough for the wind to get to the water
for it to cool down, so you might not have enough wind to blow it, to
cool it down.

(TAP) challenge and a weak rebuttal to the previous claim adding a
qualifier.

Boy 1: Yeah, but doing that ‘granny’ method everyday, it’s like you’re just
doing every method everyday whereas if you use wind then maybe you
could like . . .
Girl 1: The ‘granny’ method is like two (methods) in one because you’ve got the control where you’re leaving it and the wind is actually in the air when you’re leaving it. So the wind is actually still coming in, you’re still spreading it out and you’re still leaving it to cool down from the air.

*(TAP) Warranted and backed claim.*

Boy 2: Yeah, but you could just use a fan. You could use a fan to use as the wind.

*(TAP) New claim developed from the above.*

Girl 2: But that’s electricity and money.

*(TAP) Challenge- rebuttal to new claim of boy 2.*

Boy 1: Yeah, but if you use the fan, like when it’s not windy for a few days, and then the wind when it is windy, and then the ‘granny’ method also . . . get it done quicker.

*(TAP) Qualification added to pervious line of reasoning with a warrant.*

MH: *(to the group)* I think the interesting thing for all of us is that you’re all right. It sounds a bit strange, but every one of you is right because it depends a little bit on where you find yourself, because every one of the methods that we’ve talked about had advantages and disadvantages . . . . Because your method’s quite right *(to girl 1)*. It doesn’t cost a lot of money. The disadvantage is that you’d need a huge great lake and that might cost a lot of money or take up too much space. And your method’s fine, *(to boys 1 and 2)*. The one you were talking about together, which is great because you were listening to each other, because you could use the wind on some days and if it wasn’t windy you could turn on your fan . . . that’s actually what we do sometimes. We have a fan assisted cooling tower.

*Commentary*

As was the case for younger pupils in the Gloves MoDAS, the level of argumentation seen here is impressive, particularly as there were examples of warranted and backed claims with some rebuttals. Previous research in science lessons has shown that rebuttals are rare in the argumentation of pupils of a much older age that those studied here (Jimenez-Alexaindre, Rodriguez, and Duschl 2000) and so this observation bodes well for the further development of these pupils’ cognitive discourse, if, of course, the pedagogy of the secondary school fosters this (since some of the pupils in this study will soon transfer to secondary school). There is also evidence of some of the more sophisticated social functions of dialogue listed by Barnes and Todd (1995, 27–8) that were missing in the discourse of the younger pupils. For example, Boy 1’s premise at the start of the extract that a combination of cooling methods (surface area of water, i.e., the ‘granny’ method and wind) might be
beneficial is picked up and elaborated later by Girl 1 whose utterance clarifies this line of thinking. The development of the idea is taken further in the exchanges between Boys 1 and 2 towards the end of the extract. The point that quality discussion requires quality listening was seized on in the feedback provided by MH that closed the discussion. MH also alluded to the nature of disagreement in combining different viewpoints when he says, ‘It sounds a bit strange but every one of you is right because it depends a little bit on where you find yourself . . .’. This was an example consistent with our second aim for MoDAS, modelling ‘How science works’. The whole utterance of MH shows a degree of skill in talking with these children and providing reflective feedback on their discourse that many teachers would do well to heed.

Implications of the research

An aim of MoDAS was to promote talk in science as meaning-making and clarification of ideas. Thus MoDAS was intended to use what Barnes and Todd (1995) call ‘exploratory talk’ whereby pupils engage critically with each others’ ideas to help them construct meaning. There is evidence that such activities produce general learning gains, for example in pupils’ non-verbal reasoning skills (Howe et al. 2007). This happened in the Gloves MoDAS, though the use of another strategy to promote better talk, puppets, may have obscured the direction of discussion and therefore have affected outcomes. The ‘constructing meaning’ aim of MoDAS was discussed when planning the Heat exchange example. However, without the intervention of the author to promote this aspect in the MoDAS that closed the second lesson, the opportunity to address this properly would have been lost. Consequently, it seems there is some work to do in training teachers when using these approaches so that important values of adult modelled talk and their influences on pupils’ discourse and consequent learning of science concepts can be maximised.

Field notes revealed organisational features that helped create a purposeful climate for talk. One example was that pupils were given badges related to roles that might occur in collaborative discourse in industry:

**Administration Officer** – responsible for keeping a written or pictorial record for the group.

**Resource Manager** – responsible for collecting, setting up and returning all equipment used by the group.

**Communications Officer** – responsible for collecting the group’s ideas and reporting back to the rest of the class.

**Personnel Manager** – responsible for eliminating disputes within the group and ensuring the team works cooperatively.

It was argued earlier that using contexts from local industry help authenticate science for this age group by locating and relating science ideas in real world examples and there was plenty of evidence of HM doing this, but there is another reason. Research at the university of York shows that pupils of primary school age have few ideas about the nature, processes and job roles of industry (Parvin 1999). So MoDAS and the role badges are further steps in addressing this gap in pupils’ wider knowledge and appreciation of industry, as well as helping make abstract ideas more understandable by linking them to local, practical examples.
MoDAS is a tool to be added to teachers’ growing pedagogical repertoire through which collaborative group talk can be improved. At this age young brains develop rapidly and talk speeds the rate at which synaptial connections are made (Rose 1997). Yet in England and elsewhere the media continue to berate society for the downturn in talk opportunities amongst children. Watching TV, computer gaming and fewer family meals taken together are frequently cited causes outside the school. In school too there are pressures on time for quality talk in classrooms. The primacy of the written word continues to dominate and is exacerbated by long periods of revision in the run up to national testing at the end of Key Stage 2 (age 11). In secondary science, however, there are at last moves to change teaching away from the drudgery of didacticism towards a more dialogic approach that encompasses discussion and argumentation of ideas and controversies. As in other examples of topic work and practical skills, there may, however, be a pedagogical mismatch if pupils at transfer to secondary school have been used to a completely different approach where collaborative talk has not been part of their experience (Braund 2008). Perhaps the MoDAS approach should have applications at both stages.

Conclusions
As an exercise identifying useful features of MoDAS and pupils’ talk in groups to communicate with teachers, who have not experienced the approach, the research has been crucial. It has helped identify video from which to select clips and to devise associated questions and comments for the web-based training resource (see the AstraZencea Science Teaching Trust website). The choice of a qualitative, descriptive-analytical method to reflect on adult and pupils’ group discourse was justified. The occurrence of all four aims of MoDAS was encouraging as was the frequency of social discourse and dialogic moves and the quality and levels of argumentation. For the younger age group (7–9) there remains work to be done in helping pupils to work together more productively and collaboratively though what was seen was encouraging. As a way of promoting productive links between industry and schools and in helping authenticate science in schools MoDAS has obvious advantages. Perhaps the final word on the value of talk in human experience should belong to the novelist and essayist Thomas Mann who wrote:

Speech is civilisation itself. The word, even the most contradictious word, preserves contact – it is silence which isolates. (Thomas Mann 1924, cited in Tripp 1973, 916)

MoDAS and DiPS can be viewed at: http://www.azteachscience.co.uk.

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