

**“We talk more, we listen more, we think more, we learn more”:
changing the culture in primary science classrooms**

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Abstract

The PUPPETS Project uses puppets as a stimulus for children to engage in conversations involving reasoning in primary science lessons. Data were gathered using a range of methods, including classroom observations and interviews with teachers and children. Analysis involved the development of coding techniques to categorise episodes of classroom discourse, teachers' views and children's responses. The data indicate that puppets are engaging and motivating for children; that they promote talk involving reasoning; that they can be effective with reluctant speakers; and that they can promote changes in teachers' professional practice.

Introduction

The PUPPETS Project is a research and development initiative funded by the Nuffield Foundation, UK, which aimed to help teachers provide more opportunities for productive talk in science lessons, using puppets as a stimulus. The research focused on the effectiveness of hand-held puppets to engage primary school children's attention and promote conversations involving reasoning in science.

The value of talk in children's learning is well-documented; talking about their ideas helps children to clarify their thinking and develops their capacity to reason (Kuhn et al, 1997; Mercer et al, 2004). This is particularly important in science, as the development of conceptual understanding and the ability to use reasoning are central goals of science education. Unfortunately the type of talk that promotes reasoning and thinking is frequently absent in science lessons (Newton et al, 1999). Reasons for this may include the uncertainty teachers have about the value of children's conversations, limited knowledge of appropriate teaching strategies, and insecure subject knowledge (Osborne and Simon, 1996; Solomon, 1998).

Focused and productive talk normally requires a suitable stimulus that engages children, enabling them to feel personally involved and committed to the conversation. The use of puppets is well-established in primary schools in areas such as drama and social education (Thorp, 2005). There is some evidence that puppets can have a valuable impact in motivating children and promoting language development (Low & Matthew, 2000). Puppets can engage the children's attention, provide a context for conversation and promote purposeful activity. We believed that puppets could also act as an effective stimulus for generating talk involving reasoning in science lessons. This would build on our previous work on group interactions (Maloney, 2002) and on using concept cartoons (Keogh and Naylor, 1999), which have proved to be a powerful means of generating discussion and argument (Downing, 2005). Puppets seem to provide a mechanism for 'bringing the concept cartoons alive', with dialogue between ~~two~~ puppets or between the teacher and a puppet acting as a stimulus for children to engage with that dialogue.

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The main research questions investigated were:

- In what ways can puppets be used to enhance children's engagement and promote talk in science lessons?

- What is the impact on children's talk involving reasoning when puppets are used in science lessons?
- What is the impact on teachers' beliefs or practice in relation to talk when puppets are used in science lessons?

Methodology

The project began with a pilot phase, involving eight teachers, to develop materials and guidance for teachers to use with puppets in their science lessons. These teachers attended a workshop to become familiar with the use of puppets, after which each teacher was audio and video-recorded during a science lesson where puppets were used. In each of these lessons sample groups of children were audio-recorded during small group conversations.

Preliminary analysis of the data from these lessons led to the development of an analytical framework for classroom discourse. The focus for the analytical framework was on the nature of talk, including the use of reasoning and argument by the teachers, the puppets and the children. The pilot study also provided valuable feedback on the guidance provided for the teachers and on whether any classroom management issues were significant. The research team's preliminary judgments were tested out with the teachers at a follow up meeting, as a result of which the analytical framework and guidance were refined for the main study.

A further 16 teachers were involved in the main study, drawn from primary schools in the London and Manchester areas and covering a range of social, cultural and ethnic backgrounds. These teachers were observed and video-recorded teaching a typical science lesson. Where possible two groups of children in each class were also audio and/or video-recorded during periods of activity. Teachers were interviewed to obtain their views on the nature and value of children's talk and details about how they taught science. These initial observations and interviews provided a baseline against which future lessons could be compared. Transcripts of the teachers' and children's talk were scrutinised and the provisional analytical framework was further developed. This analytical framework was then available to apply to the data from lessons where puppets were used in science teaching.

These 16 teachers then attended a preparation meeting to provide guidance on how puppets might be used effectively, including issues such as role and characterisation of the puppets. Video clips and transcripts from the pilot phase were used to illustrate aspects of the teacher's role and how puppets might interact with the children. Teachers were requested to use the puppets in typical science lessons, taken from the teacher's scheme of work, rather than setting up special 'puppets lessons' which were separate from the usual curriculum. This was to ensure that the findings from the research would be readily applicable by other teachers working within their usual curriculum constraints.

After a period of several weeks, during which the teachers could get used to using puppets, a second science lesson was observed and recorded with the teacher using

one or more puppets as part of their teaching. As before, the teachers were observed and video-recorded. Where possible two groups of children in each class were audio and/or video-recorded during periods of activity. Teachers were interviewed and video-recorded to ascertain their views on the impact of the puppets. They also kept reflective diaries to enable them to capture their feelings about the use of puppets and record any significant classroom incidents at the time. Interviews with groups of children were video-recorded to provide data from the children's perspective. The range of data sources and collection methods allowed extensive triangulation and cross-referencing of the data. A follow-up meeting with the teachers provided feedback on the longer-term impact of using puppets and their response to issues emerging about the use of puppets in science lessons.

For various reasons not all the teachers were able to continue in the project. By the end of the main research phase data were available for 13 of the original 16 teachers.

Using an open-coding approach (Strauss and Corbin, 1998), transcripts of all the conversations between teachers, puppets and children were coded and the coding framework discussed between researchers. A set of codes was developed to identify episodes of discourse during the lesson that encouraged children's engagement and thinking. The codes were applied to discourse initiated by the teacher, the children or the puppets and recorded accordingly.

Examples of the codes used included:

- TQ: teacher asks a question which requires a reasoned answer
- TP: teacher gives procedural information or instruction
- CR: child recalls information from memory
- CA: child uses argument and/or justification for ideas
- PS: puppet creates a story, which provides a contextualising narrative for scientific ideas
- PE: puppet encourages by offering praise or positive endorsement

Video-recordings of each lesson taught (with and without the use of puppets) were analysed and categorised using these codes on an observation schedule with 30-second time intervals. This analysis enabled us to make comparisons between the time spent in various types of discourse. In addition to these codes, data were also recorded in relation to grouping of children (such as whole class, small group or individual), children's activity and interactions (such as listening, discussing, practical work, off task), the role of the teacher (such as asking questions, instructing) and the role of the puppet (similar to teacher). This enabled us to make more general judgements about the nature of the lesson, the roles of the various participants and the nature of children's interactions. A reliability check was performed by different researchers independently coding the same piece of video, and then comparing codings.

Both analytical approaches, that is, coding all the conversations and using a timed observation schedule, enabled us to determine the number of occurrences of different types of interaction and discourse, such as argumentation or reasoning questions. In

this way it was possible to compare the frequency of different types of discourse in lessons with and without the use of puppets.

Data and analysis

Children's engagement

In each class many of the children showed high levels of engagement and motivation in response to the puppets. Evidence of engagement included children asking when the puppets are to be used; physical interaction with the puppets (for example, holding their hands); following the puppet around the room; and talking to the puppets. Video evidence from lessons using puppets showed that nearly all children were focused on the puppets, that they had high levels of concentration, that they stayed on task and that they were eager to contribute to discussion.

All of the teachers noted in their diaries and/or in their interviews that puppets enhanced children's engagement. Typical comments from teachers included:

Definitely it's increased their engagement, in the parts where the puppets are active

Children were keen to tell the puppet what they knew but also listened more attentively

They get very engaged and very excited

The children responded brilliantly. I thought they may be cynical, especially the Year 5 boys, but they were especially motivated

All the children were keen to ask or answer a question and join in discussion

Analysis of interview transcripts with the children confirmed this high level of interest and engagement. Comments about the use of puppets included:

Lessons are more fun

I understand better with the puppets

Last year I didn't really find science interesting – now it's my favourite subject

You want to answer questions more

I am much more enthusiastic about learning now we have the puppets

I find it easier to listen and I'm not tempted to fiddle

Children's engagement in the lessons is a valuable aim in itself. However it is also an essential pre-requisite for thinking about scientific concepts, for talk involving reasoning and for the use of higher order thinking skills. Enhanced engagement is therefore a particularly valuable outcome from the use of puppets.

The content of children's small group conversations

Video recording of children engaged in small group conversations allowed comparisons to be made of the nature of their conversations in pre-puppet and puppet lessons.

Conversations were identified as involving 'Talk Involving Reasoning' (TIR) when children appeared to use evidence, reasoning or justification in a concept-based conversation about a scientific question. They were identified as 'Practical or Procedural Matters' (PPM) when their conversation was primarily about practical or procedural things, such as 'pass me the scissors'. Two teachers were excluded from

the data analysis because in each case there were no small group conversations without the presence of an adult in one lesson, so comparisons would not have been meaningful.

	Talk involving reasoning (TIR)	Practical & procedural (PPM)
Lesson 1 (without puppets)	48.5 mins	72.5 mins
Lesson 2 (with puppets)	128.5 mins	30 mins

There was an increase in the time that children used talk involving reasoning and a decrease in the time that they talked about practical and procedural matters in the puppets lessons. A chi-squared test shows these changes to be highly significant ($p < 0.001$). Other aspects of the data show that the total amount of time spent in small group conversations was broadly similar in lessons without and with puppets. In other words, the increase in the amount of small group talk involving reasoning represents a change in the **nature** of children's talk, not just an increase in the total amount of time made available by the teacher for talking.

Where transcripts are available they reinforce the quantitative data, showing a shift towards talk involving reasoning when puppets are used. Examples are shown in the two short transcripts below.

In the first lesson, before puppets are used, two children are cutting up strips of paper containing facts about the solar system which they are sorting. There appears to be limited enthusiasm and little challenge to their ideas.

Transcript 1: example from a non-puppet lesson

Child 6	I'm cutting it in two. I've already cut those. OK, I'm done.
Child 7	You have to put it in like this. Shall we do it in this way? Does not produce light.
Child 6	The moon.
Child 7	Write the moon on a strip of paper
Child 6	OK
Child 7	(Picks up another strip and writes down a word). The something is a source of heat.
Child 6	The sun.
Child 7	The sun. (They both read out words from another strip together – not possible to hear the conversation).
Child 6	The earth
Child 7	Oh yer.
Together	It's about 1/6 th the size of the earth.
Child 7	It's probably the moon.

Child 6	Yeh, OK you've got 3 more there.
Child 6	(Reads strip). That's easy that's the sun. OK, again it's probably the earth this time. Those are done.

In the second lesson, in which puppets are used, the same children are actively engaged in discussion. Although books are available on the desk which could potentially solve the problem they construct ideas together.

Transcript 2: example from a puppets lesson

Child 6	Yes cos you've got to kind of like, you have to tune the different like ...
Child 7	When you tune them erm... you
Child 6	You have to tune them, you make different tunes, that's why it's, that's why it's
Child 7	It's got strings
Child 6	Yes, like a piano, a piano's got strings
Child 7	You get higher and lower notes because you press down on ... to
Child 6	To make a different sound
Child 7	Yer, so not all the air gets out (gestures as if playing a recorder)

There is also a difference in the nature of children's contributions when the puppets are used. The codes CR and CA indicate whether children are recalling facts or presenting reasoned ideas and arguments. Their use of recall or argument was to a large extent determined by the opportunities presented by the teacher/puppet and the questions that teachers/puppets asked.

	Argument	Recall
Lesson 1 (without puppets)	99	389
Lesson 2 (with puppets)	244	299

The data show an increase in the children's use of argumentation and a decrease in their use of recall responses in the puppets lessons. There were more opportunities for children to develop their thinking about science in puppets lessons. These changes were evident in cases where the teacher already built a high level of opportunity for reasoning and argument before using puppets, as well as with the teachers where there was little opportunity for reasoning and argument.

Engaging reluctant speakers

Several teachers noted in their interviews that the puppets were particularly effective with shy children. They noted that children who are generally reluctant to speak in class begin to take a more proactive role and are more willing to respond to the puppets or engage in dialogue with the puppets.

For example, one teacher described a girl who did not contribute to discussions in science lessons, but '*when I use the puppets she will put up her hand and contribute*

more than before I had the puppet'. Another teacher commented on how the children 'do actually volunteer . . . and a lot of the children who wouldn't normally contribute to whole class discussion have been giving their ideas'. One teacher noted how the puppets have 'engaged some of the more needy children . . . two in particular have said an awful lot because of the puppets'. This teacher went on to describe how one girl who did not usually produce a lot of work had made a poster for the puppet and said that this was 'probably the most productive piece of work she had done'. One teacher noted that a child with English as an additional language had become more confident and able to join in with the lessons where puppets were used. In two cases children were willing to speak to the puppets when they did not engage in any form of dialogue with the teacher or with other children (ie elective mutes).

This finding was confirmed by the children themselves in interviews, where several children claimed that puppets help some of the shy children to talk more readily in class. Their comments included:

I'm not nervous talking in front of the class (with the puppet) so it's helped me – because they all look at the puppet not me (Child age 11)

The puppet explains things using less scientific words (Child age 10)

It's more comfortable talking to the puppet (Child age 10)

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. (Child age 11)

I put up my hand more with the puppet because I understand it more (Child age 11)

This impact on reluctant speakers is consistent with the way that puppets are used by teachers in other subjects. Although the use of puppets in science is rare, they are frequently used in areas where personal feelings may be an important factor, such as social education or personal and emotional development (Bentley, 2005). Puppets enable children to depersonalise the situation and to reduce the strength of feelings involved, because the dialogue is with a puppet and not with a real person.

Teachers' recall or reasoning questions

There is a difference in the teacher's questions when puppets are used. The codes TN and TQ indicate whether teachers are using questions which did not require thinking and reasoning (such as recall questions) or questions involving thinking and reasoning. In the puppets lessons, questions could be asked by the teacher or by the puppet.

	Reasoning questions	Non-reasoning questions
Lesson 1 (without puppets)	73	388
Lesson 2 (with puppets)	263	273

The data show an increase in the teachers' use of reasoning questions and a decrease in their use of non-reasoning questions in the puppets lessons. The teachers' questioning style created more opportunities for thinking in the puppets lessons.

This increase in the use of reasoning questions is consistent with the way that puppets present problems to the class. By presenting problems through puppets it appeared that teachers were less likely to retain a didactic teaching style based on recall questions, and were more likely to change their questioning style to more open reasoning questions.

Teachers' use of narrative and teachers' use of encouragement

There are other differences in the teacher's style of discourse when puppets are used. The code TS indicates when teachers (or puppets) use a contextualising narrative to set a context for learning in a science lesson, thereby creating a purpose for the activity. The data show an increase in the teachers' use of story and narrative when puppets are used. Similarly the code TE indicates when teachers (or puppets) offer encouragement to children to make a contribution and to share their ideas in the lesson. The data show an increase in the extent to which teachers offer encouragement when puppets are used. Both of these changes in teacher behaviour provide a more positive environment for learning in science lessons.

	Teacher narrative	Teacher encouragement
Lesson 1 (without puppets)	4	132
Lesson 2 (with puppets)	66	200

This change in the learning environment is consistent with the data on children's engagement (see teacher interview and children's interview data). Nearly all the children are more engaged in the lesson when puppets are used. The greater use of narrative and encouragement in these lessons goes some way to offering a possible explanation of why children's responses were different.

Facilitating changes in the teacher's practice

All of the teachers felt positive about using puppets in their science teaching, saying that they enjoyed using them and were pleased with the children's responses. All of them intend to continue to use puppets in science lessons, though one teacher intends to use them only for specific lessons so that the children do not take the puppets for granted. All the teachers appear to have settled on an arrangement in which puppets are used near the start of a lesson to present problems to children. This is when the puppets appear to have most impact and when the purpose of using them is most evident. The teachers also used puppets at the end of their lessons to explore with the children what new learning has taken place.

Although teachers were not explicitly asked to change their practice in any other way, changes in practice did indeed occur. Of the 11 teachers for whom interview transcripts are available, 9 of them claimed to have changed aspects of their practice. Five teachers noted that their lesson plans included a greater emphasis on discussion and more opportunities for the children to talk. One teacher described how he normally took on a didactic role in teaching science, but when using puppets he thought more about getting the children to talk with each other rather than just to him. Another teacher said she had planned more talking tasks and that without the puppets:

I didn't give them opportunities to talk even if they would. I didn't know whether they would (talk) because I didn't give them many opportunities to talk so that's definitely increased the amount of time for talking.

She also said her lessons had become more relevant to the children as she had linked the science they were doing to their experience.

One teacher from the pilot phase claims to be a more interesting teacher in other subjects as a result of using puppets in his science teaching. He claimed that using puppets had helped him to see the value of children's engagement and raised his awareness of how to interact with children to maximise their engagement. Another teacher described how the puppets:

... have opened me up and changed my practice to ways of thinking and ways of getting the children involved in open questions. . . it's altered the way I deliver the curriculum.

Conclusions and implications

The research indicates that puppets can provide a useful mechanism to enhance children's engagement and to promote talk involving reasoning in primary science lessons. There is evidence that when teachers use the puppets children talk more readily about scientific problems and their use of higher-order thinking (such as explanation and justification) is enhanced. They therefore appear to offer a valuable extension to the teaching/learning strategies typically used by primary school teachers in science.

The puppets can create an interactive narrative which sets a context for learning and provides a purpose for children's talk and follow-up activity. Children appear to interact readily with puppets and feel comfortable talking with them. This can be particularly significant in engaging reluctant speakers, such as shy children, and promoting greater involvement in scientific discussion with these children.

The literature on teacher change is extensive and consistent in suggesting that change in teacher practice can be difficult to achieve (e.g. Fullan, 2001). However we found that using the puppets had a greater effect on teacher practice over a short period of time than we would have anticipated from the literature on teacher change (e.g. Adey, Hewitt, Hewitt and Landau, 2004). Most of the teachers involved in the project changed their practice in significant ways as a consequence of using puppets. We know from ongoing contact with some of the teachers in the pilot phase that these changes have been long-lasting, and that they have continued to use puppets in their science

teaching. These changes occurred after only a short preparation session and with the teachers working entirely within their usual science curriculum. There were no changes in lesson timing, lesson objectives, practical activity or scheme of work. In this respect the introduction of puppets appears to compare favourably with some other innovations in science education, where more far-reaching changes are viewed as necessary for the innovation to be successful.

The project appears to have the potential to have a positive impact on primary science teaching. Funding has been secured from GlaxoSmithKline plc and Millgate House Publishing to support a programme of professional development for teachers, along with provision of resources, including puppets and scenarios in which the puppets can operate.

A number of factors have emerged from the research which appear to be relevant in ensuring that this programme of professional development is effective. These factors include:

- The project is entirely located within existing curricula. Teachers do not have to put on special puppets lessons which fall outside the usual science curriculum. They do not have to invest any additional curriculum time in using puppets but can incorporate puppets within their current Schemes of Work.
- The training programme and level of commitment that teachers are required to make to the project are modest. Teachers do not need to invest extensive amounts of time, energy or resources in introducing the project to their school.
- Teachers do not need to make major shifts in their professional practice before they try the approach in their teaching. Although involvement in the project may well lead to changes in professional values, beliefs and practice, this is not a pre-requisite for using puppets successfully.

These factors lead us to believe that teachers are likely to welcome the professional development programme, and that professional development decision-makers will be keen to gain access to the project for their teachers.

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