# CHILDREN'S INTERACTIONS IN THE CLASSROOM: ARGUMENTATION IN PRIMARY SCIENCE

Brenda Keogh
Stuart Naylor
Brigid Downing

Manchester Metropolitan University, UK

Paper presented at the European Science Education Research Association Conference, August 19-23, 2003, Noordwijkerhout, the Netherlands.

Address for correspondence:

b.keogh@mmu.ac.uk
s.naylor@mmu.ac.uk
bmdowning@hotmail.com

Institute of Education
Manchester Metropolitan University
799 Wilmslow Road
Manchester
M20 2RR
UK

**Abstract**
*The research explores the use of argumentation as an aspect of learning in science education in primary classrooms with 7-9 year olds. Data were generated through analysis of children's conversations in response to concept cartoons which led on to practical investigations. Difficulties with using established analytical frameworks led to the development and use of an alternative framework which emphasises the process of argumentation. Data were analysed mostly from a socio-cultural perspective. They indicate that children talked collaboratively to co-constuct arguments and that interruptions and non-verbal interactions were part of this dynamic process. The results suggest that effective argumentation can occur in primary science lessons and may be made more effective if teachers are aware of some of these socio-cultural factors. Teachers involved responded positively to argumentation in the science lessons and perceived benefits for young children learning science.*

**Introduction**
The importance of language in learning is well established (Vygotsky, 1978), leading to claims that learning the language of science is a major part of science education (Wellington and Osborne, 2001). One important aspect of language in science education is the use of argument, which is involved in generating and justifying claims to knowledge (Duschl, 1999) and in clarifying, persuading and resolving differences (Andrews et al, 1993).

A case can therefore be made for promoting argument in science lessons. Argument and discussion do not feature strongly in science teaching in the UK (Newton et al, 1999). Newton et al's research shows that with older secondary students debate and discussion occupy less than 1% of total teaching time. Osborne et al (2001) note that the use of backings and theoretical justification for warrants is typically lacking in secondary classrooms. Solomon (1998) puts forward some reasons why science teachers tend not to use discussion and argumentation as tools for teaching and learning, including lack of skill in managing the process and uncertainty as to its value. To date most of the research into argumentation has taken place with secondary pupils. This research was carried out in primary classrooms to complement the data already available for secondary.

The focus for this research was to generate and analyse argument in primary science lessons. The research question was to ascertain whether younger pupils could engage in purposeful argumentation in science, the nature and role of the argument and to identify potential benefits of argumentation with younger children in science lessons.

**Methods**
The research strategy was to use concept cartoons with primary age pupils as a stimulus for discussion and argument. Research into the use of concept cartoons reveals that a typical response involves high levels of engagement and motivation, purposeful debate and justification of alternative ideas (Keogh & Naylor, 1999). Pupils, teachers and researchers describe this response as argument, and this response is evident with primary age pupils as well as older learners. The argumentation resulting from the use of concept cartoons was identified and analysed using an analytical framework. Analysis of the

quality of argumentation then enabled provisional judgements to be made about some of the factors which appeared to influence argumentation.

The concept cartoons were used initially as an elicitation strategy which helps pupils to clarify their thinking and generates the need to resolve the cognitive conflict which the arguments reveal. Elicitation "*is the first stage in a process of determining what they (the pupils) want to know and helping them to develop their ideas*" (Millar and Murdoch, 2002: 29). Pupils were invited to engage in further enquiry as a result of their argumentation, so that argumentation was integrated as a purposeful aspect of scientific enquiry in which pupils recognise the need for evidence to resolve the argument.

The main data sources were two classes of 7-9 year olds. Their conversations were recorded using audiocassettes and transcribed for analysis. Field notes recorded aspects of their non-verbal behaviour. Follow up interviews with the children enabled the interpretation of the transcripts to be cross-checked. Interviews with teachers were used to explore their perceptions of the pupils' engagement in, and outcomes of, the lessons. Concept cartoons were used as the stimulus for argumentation in the context of a 'typical' science lesson rather than lessons set up purely for research purposes. The children were able to carry out a practical investigation to resolve any differences of opinion revealed through their argument.

Analysis of the transcripts initially attempted to use well established frameworks from Toulmin (1958) and Mercer et al (1999), which take a semi-quantitative perspective on data analysis. However there were major inconsistencies between the outcomes of the use of the frameworks and the argumentation actually observed. An alternative model, the Downing model (Naylor, Downing and Keogh, 2001), was therefore developed using grounded theory to characterise what appeared to be significant aspects of the pupils' argumentation and to represent these in a new analytical framework which was then tested against classroom observations. This model takes a more qualitative approach to data analysis and emphasises argumentation as a dynamic process rather than the specific content or structure of the argument.

The transcripts were analysed with annotations to indicate where non-verbal interactions occurred. The analysis took account of socio-cultural factors in the classroom, which a pilot study suggested may be important. These factors included group dynamics, teacher intervention and gender.

**Results**

The majority of the transcripts appeared to indicate that children were talking collaboratively and co-constructing arguments. This appeared to be the case even though they had not received any training in argumentation and the teacher was not present to direct their conversations. Children typically appeared to have a common goal of reaching a shared understanding. They would begin discussions with different points of view about the science involved and contribute their ideas. From that point onwards they tended to build on each other's contributions in order to reach a shared understanding.

There were some examples of direct rebuttals of another's claims, but these were infrequent. Conversations were typically dialogical and interactive, often overlapping, rather than following a monological chain of reasoning. Interruptions generally reflected this collaborative mode of working. Although in principle interruptions might be disruptive, there were many examples of supportive interruptions and of children indicating a desire to speak without interrupting the speaker. Interruptions frequently took the form of agreement with the speaker, clarification of meaning, supportive evidence being put forward, the next step in a chain of reasoning being offered, and so on.

The transcript below (transcript 1) illustrates a group of children co-constructing an argument. The class are nearing the end of a sequence of work about forces and motion. They have covered work on gravity as a force giving objects weight, friction as a force slowing moving objects, air resistance and balanced/unbalanced forces. Claire, Donna, Joe, Mairi, Rosie and Simon make up a higher achieving group of 9 year-olds who are used to working together. They are discussing a concept cartoon showing what forces will be acting as a person moves on a skateboard.

| | | | | |
|---|---|---|---|---|
| Simon | *(Reading) There must be a force that keeps her moving.* | | | |
| | | *(Reading) The only force acting is friction* | Rosie | |
| Donna | *(Reading) If there isn't any friction she will keep moving* | | | |
| | | *(Reading) She isn't pushing so there can't be and force* | Claire | |
| Simon | He is not right, that one *(pointing).* Friction is not the only force. | | | |
| | | No, 'cos gravity | Rosie | |
| Donna | Yeah, gravity. Well I mean that is always there. | | | |
| | | Yeah but that like, well it is a force but well, you know it kinda isn't, well like it doesn't make you move | Joe | |
| Donna | What is friction? | | | |
| | | Oh that, well don't you remember right, when we did right, the cars on the slope thing, with the sandpaper, you know | Simon | |
| Rosie | She (Donna) was away | | | |
| | | Yes but, I know. We did it before it I think. | Donna | |
| Joe | Good right well then I think that one is right then *(pointing)* | | | |
| | | Which? | Claire | |

| | | | | |
|---|---|---|---|---|
| Joe | *(Reading) If there isn't any friction she will keep on moving* | | | |
| | | She won't though. Not forever! | Rosie | 1, 4 |
| Mairi | No but well that is because there is friction, isn't there and well right so she will stop right, she will but right *(reading) if there **isn't** any friction* | | | 1 |
| | *she will keep on moving* | She will keep on moving! Exactly. That is what I just | Joe | 1 |
| Rosie | Yeah<br>so he is right definitely | said. | | |
| | | And he is wrong, definitely | Simon | 1 |
| Claire | So that leaves those two. Him and him *(pointing).* | | | 1 |
| | | So either the force. There must be a force that keeps her moving or there isn't | Mairi | 1 |
| Joe | Because she isn't pushing | | | 1 |
| | | Well when I'm on, I have a skate board at home and well. . Okay so, when right you're on a skateboard and you well you push off right and if right you don't push off again right well then you just stop | Simon | 1 |
| Joe | You don't just stop, you slow down. Don't you. Like a car with the brakes … | | | 1 |
| | …on | Yeah, yeah you slow down because of friction | Simon | 1, 2 |
| Joe | Yeah friction, yeah so right that is | | | 1 |
| | force that … | Friction slows her down and so does wind | Claire | 1, 2 |
| Joe | Wind yes if she was going in, like if the wind was, if the wind was from the front, I mean that could be pushing her from behind | | | 1 |
| | | The wind could be pushing her yeah great, so she could like be pushed by the wind | Mairi | 1 |

| | | | | |
|---|---|---|---|---|
| Donna | A strong wind could. . | | | |
| | | So right she pushes off, right with her feet. | Simon | 1 |
| Joe | Yes she has to like start it | And then the wind will… | | 1, 2 |
| | | Okay so right she pushes off with her feet to start off then right the wind keeps her going but right friction makes her slow down and stop. | | |
| Rosie | top<br>And stop | | | 1, 2 |
| | | Unless the wind was too hard. Then she wouldn't stop | Donna | 1 |
| Joe | Well the friction will stop her eventually. She can't keep going forever. | | | 1 |
| | | No so right the friction right, the wind will keep her going right and the friction will slow her down so right when they balance… | Claire | 1 |
| Simon | When they balance she will stop. | | | 1, 2 |
| | | Equi –lidi. …that thingy | Joe | 1 |
| Simon | Equi-lid-ihibru | | | 1 |
| | | Well whatever, that. The forces will balance and everything is stop | Joe | 1 |
| Rosie | Cool. So right. We've done those two, right and then these two so right now well he is right then. | | | 1 |
| | | No wrong. Because she stops remember | Joe | 1 |
| Rosie | Yes, friction yes that's the friction one init so right but right that's that one and right | | | 1 |
| | | The wind. The wind is like the force that keeps her moving | Claire | 1 |
| Rosie | Exactly so he is right and he is wrong. | | | 1 |
| | | Two right and two wrong. Good. | Claire | |
| Mairi | We've finished | | | |
| | | So no wait we've not 'cos now we design an experiment to prove we're right. | Rosie | 3 |
| Simon | Evidence! | | | 3 |

*Transcript 1: skateboard*

The points marked 1 in the transcript show the children in the group co-constructing an argument with the clear goal of reaching a common understanding rather than proving that an individual is right. The points marked 2 show examples of interruptions which did not disrupt the flow of the conversation and which in many cases were supportive of the speaker, contributing to the con-construction process. This type of dialogue was typical of groups of children co-constructing arguments through interactive dialogue. It is apparent from the transcript that attempting to evaluate the argument through analysis of each individual's contribution is extremely difficult. Data and claims are frequently inseparable and the forms of speech used do not readily lend themselves to linguistic analysis.

It is notable that there is no teacher intervention or teacher direction of the children's conversation. They engage in a focused argument, drawing on experience and evidence to justify their views, without any formal training in argumentation. The engaging stimulus for their conversation and their common goal of reaching a shared understanding are likely to be significant influences in keeping their conversation focused in this way.

The dialogue at 4 appears to show a direct rebuttal. In this instance the point being contradicted is the statement in the concept cartoon which Joe is reading. Joe appears to agree with this statement, but the rebuttal is directed more at the statement in the concept cartoon rather than at Joe. In this respect the concept cartoons appear to empower children to disagree by depersonalising the ideas so that disagreement between the children also becomes depersonalised.

The second transcript below shows another example of co-construction. Simon, Aiden, Stuart and Michael are a group of 9 year-old boys. They are discussing a concept cartoon which poses the question of whether two overlapping shadows will be darker than a single shadow.

| | | | | |
|---|---|---|---|---|
| Simon | So what have we got to do? | | | |
| | | Decide which is the right answer, which that one is *(pointing)* | Aiden | |
| Stuart | No way is it. Man you are so wrong. Look that . . | | | 5 |
| | | *The shadow is twice as dark where the shadows overlap (reading).* Two shadows, two lots of dark. Make sense. | Michael | 5 |
| Aiden | Nah mate. The shadow is twice as dark. See look, ***the*** *shadow (reading).* The equals one. Once not twice. Get it? | | | 5 |
| | | What? | Michael | |

| | | | | |
|---|---|---|---|---|
| Stuart | Man, what are you on about? Look at the picture. Look at the shadow there *(pointing).* | | | |
| | | Stu, that's just a drawing. Not a photo or nothing. You can make a drawing anything. Them kids have no arms, see. Just a picture. | Aiden | 5 |
| Simon | Right, wait. So what are you saying man? | | | |
| | | Right, okay, so what makes a shadow? | Michael | 5 |
| Aiden | The sun | | | 5 |
| | | . . or a torch | Stuart | 5 |
| Michael | Nah, listen, it's the tree | | | 5 |
| | | It ain't | Aiden | |
| Michael | Yeah, yeah, the tree makes the shadow | | | |
| | | So the tree standing in the night makes a shadow? | Aiden | |
| Stuart | What? No way does it. It's the sun makes the shadow, mate | | | |
| | | That's not the answer. The sun makes the shadow. We got to pick one of these *(pointing)* | Simon | |
| Michael | Yeah, but right. See there's the sun and there's the shadow | | | |
| | | Yeah, like I said. The sun. The shadow. Just one all the same. | Aiden | |

*Transcript 2: shadows*

In this transcript the conversation is fairly symmetrical, with no individual exerting a dominant role. The dialogue tends to be rather fragmented, with short or incomplete sentences (see 5 in transcript 2) which were frequently overlapping or simultaneous. The transcript gives the impression of a collaborative group that is 'thinking out loud' in an attempt to work out the problem together. In transcript 2 there is a strong sense of all the children being involved in exploring the ideas, but each statement appears to assume much of the information contained in previous statements, so that each new statement is relatively short. The boys' form of speech appears to emphasise short stylised comments rather than lengthy, well constructed paragraphs.

The following transcript shows a group of four nine year-olds (Scott, Jason, Ryan and Danielle) discussing the same situation with a concept cartoon which poses the question of whether two overlapping shadows will be darker than a single shadow. The transcript starts partway through their conversation

| | | | | |
|---|---|---|---|---|
| Danielle | We need to design a test then | | | 3, 6 |
| | | Okay, you do that | Ryan | |
| Danielle | No, we need to | | | 6 |
| | | We need to get two trees and overlap them | Scott | |
| Jason | Not the trees, just the shadows | | | |
| | | Well yes. That's what I did mean | Scott | |
| Danielle | That's useless. We can't move trees to overlap them. They're way too heavy. | | | |
| | | No, not trees. Just shadows. | Scott | |
| Ryan | Shadows aren't heavy | | | |
| | | We can't do that. Not inside. | Danielle | 6 |
| Jason | True | | | |
| | | True | Scott | |
| | | . . so inside we have to use something else | Danielle | 6 |
| Jason | True | | | |
| | | True | Scott | |
| Ryan | But what though? | | | |
| | | That is the tricky bit | Danielle | |
| Jason | True | | | |
| | | Stop saying 'true'. It's dead annoying. | Danielle | |
| Scott | True | | | |
| | *Sounds of laughing* | | | |
| | | No. Right we will use pencils then, okay? Pencils. Scott, write 'pencils' | Ryan | |
| Danielle | No, that's useless. Pencils don't overlap shadows. We need something else. More treeish. Like okay, see my hands, right. I can make them like trees, with the branches like my fingers. See. I can overlap *(overlaps* | | | 6 |

| | | | | |
|---|---|---|---|---|
| | *fingers)* but, right pencils, they just cross over. See? | | | |
| | | Oh, okay. We'll use hands then. | Ryan | |
| Danielle | No, that's not good. We can't use, I mean I just showed you but just to show. We need something else. Objects. They must be objects. Otherwise it's not like science. | | | 6 |
| | | Pencils and plasticine. We could use plasticine. To make like tree shape things. | Scott | |
| Danielle | Yes, that's good. So Scott, you write down we need pencils and plasticine. | | | 6 |
| | | And a torch. We will need a torch. | Scott | |
| Danielle | Yes, good. What else? | | | 6 |
| | | Shall I write 'torch' then as well? | Scott | |
| Danielle | Yes, yes. Write everything we need | | | 6 |
| | | Bossy. Girls are dead bossy. | Jason | |

*Transcript 3: shadows*

Transcript 3 shows a good example of one child taking on the role of a teacher (6 in transcript 3). Danielle, the only girl in the group, asserts her status by organising how the group will undertake the activity, determining the direction of the conversation and by adjudicating between the suggestions put forward by the boys. Her own thinking appears to develop as she explains her reasoning. For most of the interchange the boys are content to accept her authority and to go along with her suggestions, though Jason chooses to isolate himself and to attempt to undermine Danielle from the sidelines. This transcript also illustrates how gender did not generally appear to be a significant influence in how discussion and argument developed. In this case a girl takes the leading role; in others the reverse is true; in some (such as transcript 2) there is no dominant child who takes on the role of a teacher. In groups where the numbers of boys and girls were equal the boys made slightly longer contributions, but this was not statistically significant.

Transcript 4 shows a short interchange amongst a group of six 9 year-olds who are discussing a concept cartoon which shows various possibilities for what might happen when you kick a football.

| | | | | |
|---|---|---|---|---|
| Sophie | Is it *It comes down because it* | | | |

| | | | | |
|---|---|---|---|---|
| | *runs out for force* or is it *it comes down because there is no upwards force after you have kicked it?* | | | |
| | | They are the same really | William | |
| | *general murmerings of agreement* | | | |
| Sophie | Yeah, Yeah that's true they mean the same | | | |
| | | Actually they all do, those three | Caleb | |
| Andrew | Only this one is different because it blames gravity | | | |
| | | Well yes, but really when you think about it that is the others are the same. | William | |
| Andrew | So they are all right. . | | | |
| | | . . or all wrong. I guess we decide. | Caleb | |
| | *Further conversation. The teacher comes over* | | | |
| Teacher | Okay red group. What's the problem? | | | |
| | | Well Miss, you see those three answers, well they are all the same. | Lauren | |
| Teacher | How do you mean the same? | | | |
| | | Well you see they are all like the same thing | Lauren | |
| Teacher | Okay. Well I don't think they are the same. Andrew do you? | | | |
| | | No Miss. But … I mean, well they are kinda a bit the same. | Andrew | |
| Teacher | A bit the same. Caleb? | | | |
| | | Well. I mean…well we said …erm well right so take *If I kick the ball high enough it will never come down* right well that means right that the ball right, it well right that one is not true, is it? so right well it's… | Caleb | |
| Teacher | Okay, so you don't like that one. But are the other's the same? Sophie? | | | |

| | | | | |
|---|---|---|---|---|
| | | No Miss Jackson. | Sophie | |
| Teacher | So what is the problem?… Isaac? | | | |

*Transcript 4: football*

The impact of the teacher's presence is clear. The children no longer talk to each other but now engage in dialogue only with the teacher. The teacher controls the direction of the conversation, asks direct questions of individuals, adjudicates when they respond and becomes the most dominant voice in the conversation. This was a common occurrence in the transcripts: when transcripts recorded the presence of a teacher the shift in the group dynamics appeared to disempower the children and reduce the length and intensity of their involvement in argumentation.

Argumentation generally resulted in the children carrying out practical investigations to resolve the argument. At some point in their argument they would realise that they did not have enough information to reach a definitive answer. Sometimes they could definitely exclude some of the alternatives but still be unable to make a choice between two or more of the possibilities. Their previous experience of science reinforces the view that the most effective way to find out about a scientific problem is to do a practical investigation. In this research the concept cartoons frequently gave strong hints as to what kind of investigation would be appropriate. An example of how children reached the point of recognising the need to obtain further evidence is shown at 3 in Transcript 1, while at 3 in Transcript 3 there is an example of how the children continued their argument with a new focus on how to set up a practical investigation.

**Conclusion and implications**

Analysis of transcripts from primary science lessons indicates that relatively young children are capable of collaborative interaction and of co-constructing arguments through verbal and non-verbal means. The nature of the arguments in which the children engage is typically interactive, overlapping and collaborative rather than sequential and confrontational. The children are able to stay on task and to remain focused on a purposeful interchange of ideas. Concept cartoons appear to be an effective stimulus for generating this collaborative interchange of ideas.

The arguments appear to be beneficial in primary science in focusing the children's attention on the range of ideas that they hold and in helping them to investigate purposefully. Argumentation provides opportunities for children to assert claims to knowledge, to justify and evaluate those claims and to review the evidence available to sustain those claims. These arguments therefore appear to be scientifically worthwhile, even though the children had not received any training in argumentation.

Good argumentation appears to share many features with small group collaborative learning. It is possible that guidance in appropriate ground rules for collaborative discussion could be valuable in helping the children to organise their discussion on the most effective basis; alternatively it may be that the use of structured rules for the discussion would reduce the spontaneity and inhibit the flow of the conversation. Group

dynamics and socio-cultural factors, including the presence of the teacher, appear to be influential in determining the nature and direction of the arguments. They suggest that argumentation is more likely to be effective in small groups and that teacher-led whole class discussion is likely to lose many of the benefits of argumentation. Teachers may be able to enhance effective argumentation in primary science if they are more aware of some of these socio-cultural factors, including their own influence on the nature of argument.

**Bibliography**


Andrews, R., Costello, P. and Clarke, S. (1993) *Improving the quality of argument 5-16: Final Report*. Esmee Fairbairn Charitable Trust/University of Hull.

Duschl, R., Ellenbogen, K. and Erduran, S. (1999) *Understanding dialogic argumentation among middle school science students*. American Educational Research Association Annual Conference, Montreal, Canada.

Keogh, B. and Naylor, S. (1999) Concept cartoons, teaching and learning in science: an evaluation. *International Journal of Science Education*, 21, 4, 431-446.

Mercer, N., Wegerif, R. and Dawes. L. (1999) Children's talk and the development of reasoning in the classroom. *British Educational Research Journal*, 25, 1, 95-111.

Millar, L. and Murdoch, J. (2002) A penny for your thoughts. *Primary Science Review*, 72, 26-29.

Naylor, S., Downing, B. and Keogh, B. (2001) *An empirical study of argumentation in primary science, using concept cartoons as the stimulus.* European Science Education Research Conference, Thessaloniki, Greece.

Newton, P., Driver, R. and Osborne, J. (1999) The place of argumentation in the pedagogy of school science. *International Journal of Science Education*, 21, 5, 553-576.

Osborne, J., Simon, S., Erduran, S. and Monk, M. (2001) *Enhancing the quality of argument in school science*. European Science Education Research Conference, Thessaloniki, Greece.

Solomon, J. (1998) About argument and discussion. *School Science Review*, 80, 291, 57-62.

Toulmin, S. (1958) *The uses of argument*. Cambridge: Cambridge University Press.

Vygotsky, L. (1978) *Mind in society: the development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Wellington, J. and Osborne, J. (2001) *Language and literacy in science education.* Buckingham: Open University.