Figure 1 A small year 4 group discuss reasons for agreeing or disagreeing with the class's ideas downloaded from the whiteboard

Developing 'argumentation' with the 4–11 age range

Terry Russell *and* **Linda McGuigan** *of the University of Liverpool draw on their classroom research to offer their thoughts on argumentation, an aspect of 'working scientifically', with contributions from two recent research collaborators:* **Janet Hamilton** *teaching 4–6 year-olds and* **Joanne Geldard** *teaching science to 10–11 year-olds. Between them, they offer a developmental perspective on supporting children's capabilities in this area.*

Argumentation, as we discuss it, is nothing to do with quarrelling or raised voices: think rather of children learning to engage in reasoned discussion. Mercier (2011: 179) argues that '*reasoning should help us create new beliefs, generate knowledge and drive us towards better decisions*'. Argumentation parallels the manner of professional scientists resolving their differences through the calm and measured medium of publications in research journals. In the context of primary science, we define argumentation as '*the teacher-managed exchange of ideas-with-evidence between learners*'. Later, this definition can be expanded to '*the coordination of evidence and theory to support or refute an explanatory conclusion, model or prediction*' (Osborne, Erduran and Simon, 2004: 995).

Argumentation as communication and knowledge construction

The essential communicative aspect of argumentation requires children to express their own ideas clearly and listen attentively to those of others. In doing so, they draw on the skills of discussion, dialogue and conversation. Such exchanges of points of view are referred to as 'science discourse'. Evidence is required to back up statements (aka 'claims' or 'propositions') and resolutions can result in new meanings and understandings, or 'knowledge construction'. So argumentation is a social phenomenon requiring some formal procedures to be adopted. Only then will interactions rise above the level of playground disputes and be rightly described as a mode of 'working scientifically'.

Key words: Research Literacy

The beginnings of argumentation

In experimental situations, early-years children have shown the capability to use evidence and reason scientifically, but this refers to contexts when they have been asked to reason about evidence that has been provided for them (Piekny and Maehler, 2013). In contrast, our research (Russell and McGuigan, 2016) has been conducted in real-life settings and classrooms. We have been surprised at the capabilities shown by even young children. This article shares some of the successful practices that we were privileged to observe.

Learning to listen and respond positively using everyday experiences

When we visited Janet's classroom (4–6 year-olds), she was working on the topic of 'materials', taking a cross-curricular approach with an emphasis on speaking and listening. She explained, '*As part of our materials project we had been focusing on the skills of expressing ideas and opinions and listening and replying to others … the children had already built up a basic knowledge and understanding of materials and their properties*'.

Janet used everyday practical experiences and concrete objects to start children thinking. Direct involvement provides a clear focus for group discussions. Her specific aim was for children to use their developing knowledge of material properties, in conjunction with speaking and listening skills, to negotiate the designing and making of outdoor sound instruments: '*To further the children's understanding of how and why materials are used and to develop their ability to listen and reply to others I decided to take them on a materials walk*'. The walk was deliberately planned to take place in the rain, offering children opportunities to observe, compare and discuss the properties of materials when wet. Children were encouraged to decide whether they agreed or disagreed with one another's ideas.

Using 'because' to encourage reasoning

Children discussed whether rain could 'sink in' to metal or wood:

I don't think water can sink into metal because metal is too hard and it hasn't got any holes in it to let the water in.

When it rains, the wood goes darker.

JH: *Because …?*

Because the water is coming through the holes.

JH: *And where does the water go?*

It sinks into the wood.

In this dialogue, a child observes that wood gets darker when wet, followed by the hypothesis about water getting into holes and sinking in. This statement demonstrates pleasingly active scientific observation and reflection. Janet's follow-up request for a reason by using the quizzical '*Because …?*' is exemplary. The expectation that any and every statement should be backed up with a justification is an essentially scientific way of behaving. Reasons may take the form of evidence or an explanation. Our classroom visits confirm that, prior to instruction, ideas as *assertions* tend to be more prevalent than the justifications to back them up. Encouraging the use of 'because' in children's exchanges succeeded in cueing them to offer reasons to support their ideas.

Giving and receiving feedback sensitively

Children need to be confident about handling feedback on their thoughts, rather than apprehensive about potentially threatening and deflating comments. Encouragement to be 'brave' in their contributions and 'kind' to others in their feedback can be very helpful. As children interacted, Janet modelled sensitive feedback strategies using key phrases such as, *'I like Ethan's idea but …'*. This 'critically friendly' positive but questioning form of response was rapidly taken up by children, once they had been encouraged to be positive in their first reactions to others' expressed ideas. This might then be followed up by a gentle challenge to the idea. In learning the niceties of the technique, the truth of any claim was, initially, of secondary importance to the fact of a contribution with justification having been added to the discussion. The act of overtly expressing appreciation of other children's input proved significant. Janet summarised children's developing argumentation skills with these words:

They were developing their ability to listen and to respond appropriately using relevant vocabulary and language. The children developed an ability to have, and express, ideas leading to argumentation. Several of the group were able to comment on others' ideas, saying whether they agreed or disagreed and giving reasons for their views.

Active listening

As adults, we know that listening with care and attention is a valued, albeit variable, skill. Listening with empathy and attention is as essential to argumentation as communicating information accurately. Children in Janet's class demonstrated in their thoughtful responses that they were receptive to others' ideas, able to compare them with their own and capable of responding in ways that would enhance one another's learning. Active listening also requires seeking clarification where needed and offering feedback to help cement new understandings. A variation used in other classes was for children to record tentative ideas on paper, each viewpoint being reflected upon in turn. Initially, this reflection might encourage individuals, pairs or small groups to make agree/disagree judgements that would serve as a rehearsal for class discussion (Figure 1).

Argumentation with 10–11 year-olds

Managing whole-class science argumentation sessions had been a new challenge for Joanne. She described how, following her initial attempts, the sessions were much more productive second time around with a new group. As researchers, we were keen to learn what had changed. Joanne noted that on the second occasion:

The children were so, so, so brilliant. They debated with each other, questioned each other, clarified each other's thinking, picked up on each other's points, etc. etc. In fact, everything I'd hoped they would do. The discussion was amazing! The main positive difference was that the more recent group truly listened to each other to establish agreement and shared understanding through a joint attempt to clarify ideas. There was an absence of seeking the limelight, or competition, where the exchanges might have had a hint of competing rather than trying to understand one another's viewpoint.

The emotional and interpersonal needs of individuals in the group

Joanne realised that children needed argumentation to be modelled, so in dialogue with her teaching assistant (TA) she acted out some argumentation exchanges, both in the style she wanted to support and by dramatizing some of the behaviours she wanted to discourage: '*So when we had a very closed conversation, the children could see we were getting nowhere fast*.' By playing naïve, Joanne put herself in a role in which '*the TA gently reshaped my thinking, words and ideas … I also put into my questions my deliberately wrong ideas … and the TA wasn't laughing at my misunderstandings*'. These interactions modelled reasoning with evidence and listening actively to fully understand the other's point of view.

Figure 2 Justifying the choice of materials and design to peers (age 5 years)

Key phrases that act as a 'style guide'

Just as Janet had, Joanne introduced some key phrases that provided children with useful guidelines for moderating their own input:

They paid attention when I used key phrases to get the debate back on track and then used these themselves. I think this is a class in which children have been used to listening to one another and are respectful towards each other and so they just 'got it'. In fact, if it had been videoed people watching would say, 'Oh, you never get classes like that! It's obviously rehearsed.'

The kinds of phrase Joanne introduced were positive and encouraging, empathic, never negative:

- **That's interesting, but can you explain that to me a bit more?**
- **You said X but did you mean Y? Because I could see how that would have an effect.**
- **I don't understand that word. What does that mean?**
- **Yes, but if that happened, how could this have happened?**

As Joanne said:

I was trying to teach the children that we weren't going to shoot down in flames the first idea that was presented but rather wanted to tease out from the contributor what they meant.

An example was when:

a girl said she thought earthquakes might have made dinosaurs extinct. And then another girl piped up and said, 'Mm, earthquakes. Yes, I can see that, but I think you might mean volcanoes.' And so the discussion developed and they managed to discuss about four or five reasons why dinosaurs might have become extinct.

The teacher's subject matter confidence is a bonus

Joanne noted that her own increased confidence with the subject knowledge contributed to the smoother running of the later session. Lively discussions entail unpredictability, unexpected twists. Everyone must be allowed to contribute, but, equally importantly, the discussion must be gently steered to remain productive. Teachers can monitor children's reasoning and feed links between ideas back into the discussion. This helps children to keep track of the different claims and accumulating arguments. A teacher's familiarity with the subject matter relieves some of the burden of dealing with surprising inputs. Experience certainly helps!

Children's own familiarity with the subject matter

A more positive exchange of ideas is possible when children have prepared themselves for the debate with some scientific understanding. As part of the project, some teachers organised what were referred to as children's 'research meetings', where children used their information gathering to support their ideas. This tactic helps to focus the discussion on contributing and exchanging new conceptual understanding, rather than asserting personal beliefs. Joanne explained:

Then they are more likely to genuinely listen to each other and question supportively what they say … they really are interested in learning more and deepening their knowledge: 'Oh yeah, I hadn't thought of that. Oh, so that's what that means! Oh, I get it now.'

The strategy is not so much one of persuading others of a particular viewpoint but of engaging together to examine arguments and construct new knowledge.

In conclusion

Establishing confidence with argumentation is best seen as a whole-school, long-term, cross-curricular project. From their first entry into education, we must assume that every child has ideas to contribute and build a supportive climate to avoid apprehension and facilitate expression. Concrete objects, drawings, models (Figure 2) or actions help to disambiguate the subject matter, so that argumentation becomes seamless with practical activities. Listening has to be treated as an active rather than a passive process, signalling being alert and having understood or seeking clarification when the message is unclear.

Following different trains of thought in the class argumentation process can be complicated for teachers as well as children! Prior critical reflection on information in pairs and small groups offers children invaluable rehearsal opportunities. Children's research using secondary sources or practical investigations offers useful jumping off points for exchanging ideas; some familiarity with the subject matter helps clarity of thinking and undoubtedly helps the discussion to flow.

The developmental perspective we have outlined confirms the progress children can be helped to make across the 4–11 age range, so that argumentation becomes an invaluable means of extending science knowledge. Rather than a skill to be turned on and off, reasoned discussion is better thought of as something more permanent, habitual and constantly available – in children's social lives and at home. Insights into a more productive approach to argument may also be appreciated by parents and suggest constructive interventions when '*Stop that arguing*' is on the tip of the tongue!

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