Activities for promoting small-group discussion and argumentation

Shirley Simon and Jane Maloney

Activities in different formats are used to promote autonomous small-group discussion and argumentation

The rationale for teaching argumentation in science has been fully developed by previous articles in this and other science-education journals (Osborne *et al.*, 2001, 2004, 2006). Essentially, it is important for children to understand that science is a process of rationalisation and that observations do not lead to self-evident conclusions. In order to appreciate the origins of scientific knowledge, children need to explore some of the reasons why accepted ideas have become established and why alternative theories are considered to be 'wrong'. Moreover, they need to experience the kinds of arguments that would help to establish scientific theories, through engaging in activities that invite them to evaluate the evidence that might be used in such arguments.

Kuhn (1993) suggests that argumentation can help children to develop their scientific thinking. She conceives 'science as argument' in terms of science being a social activity that advances through discussion between people. If we are to encourage children to develop their scientific thinking we need to teach them how to argue about their ideas in order to clarify what they think and then how to argue for their ideas when they try to convince others of their merits. An essential precursor to the successful development of argumentation in school science is the provision of suitable activities that stimulate children and engage them in discussion. With properly designed activities and appropriate resources, collaborative working can facilitate the development of children's scientific reasoning skills as they seek to justify an idea and convince others. Children may argue from different positions and in presenting their reasons for a particular standpoint they will be challenged in their own thoughts and also challenge evidence that opposes their view.

ABSTRACT

A research project undertaken with children in year 6 (10–11 year-olds) was designed to investigate how children use evidence and argumentation in solving problems in science. The study focuses on four different activities that present children with a problem to solve and evidence to use, which they can discuss in small groups to make decisions. The study found that all groups were able to engage in the activities to some extent, but that good quality argumentation arose when children were familiar with working in this way, and when they took on positive roles within the group.

The recent emphasis on the value of teaching approaches that focus on purposeful 'dialogic' classroom interactions (Alexander, 2005) highlights the need for teachers to be prepared to allow children to question evidence, and to break away from forms of classroom discourse where they ask questions (to which they know the answers) and evaluate children's responses in a fashion that excludes many children, or leaves them confused. Decision-making activities can help teachers to create alternative classroom climates that are more dialogic and promote classroom talk. An analysis of how children interact whilst engaged in such activities can help teachers to understand the advantages of such an approach. Mercer *et al.* (2004), for example, have shown that teaching interventions designed to promote 'exploratory' talk can enhance children's thinking, reasoning and understanding in science. A move towards more dialogic practice can be facilitated by the use of activities that enable groups of children to engage in discussion autonomously without constant intervention.

This article reports on the design and implementation of activities that can be adapted to support teachers' work in ideas, evidence and argument in science. The research was an

investigation into the ways in which children engage in small-group discussion and use evidence to make collective decisions (Maloney and Simon, 2006) and contributes to our understanding of how children can be encouraged to develop argumentation skills. The research was carried out with five groups of four children in schools in the London area, all from year 6 classes (10–11 year-olds). The children, selected by their teachers, were able to read independently and were capable of working in a group without continuous teacher intervention. Each group worked independently and was observed by the researcher, who video-recorded the session. The findings are drawn from transcripts of the groups' conversations and individual interviews with the children after each activity.

Four activities for small-group discussion

Four decision-making activities that encourage discussion and argument were designed to reveal differences in opinion so that children could explore their reasoning and expose their thinking whilst working autonomously. In each activity the potential evidence was presented in different formats, for example, pictures, written information, or data from a scientific investigation; see Box 1 for a summary of the formats. We report on the success of the different formats in encouraging debate and argument amongst small groups of children.

Each of the different formats facilitated group discussion as will now be explained. Details of each activity are provided with an indication of how the format could be adapted for different contexts.

BOX 1 Formats for the four decision-making activities

Activity	*Formats of the potential evidence*
1	Information in the form of pictures and text was provided and the group was asked to use this information to make a decision.
2	The group was asked to make individual suggestions as to how to solve a given problem. The group was then given information that could be used to review the decisions made.
3	Experimental data were provided and the group was asked to use this information to make a choice.
4	Written records of children's experimental methods and their data (which contained anomalous results) were given to the group who had to discuss what might have caused the anomalies.

Activity 1 Gerbils: decision-making using pictures and text

The problem is shown in Box 2.

One of the reasons why this proved to be a good activity in promoting discussion and argumentation was because the 'best' home is not obvious; all three homes provide food, water and what appears to be a safe environment for gerbils. However, Home 3 is the most suitable as it provides conditions that are most like the gerbils' natural environment:

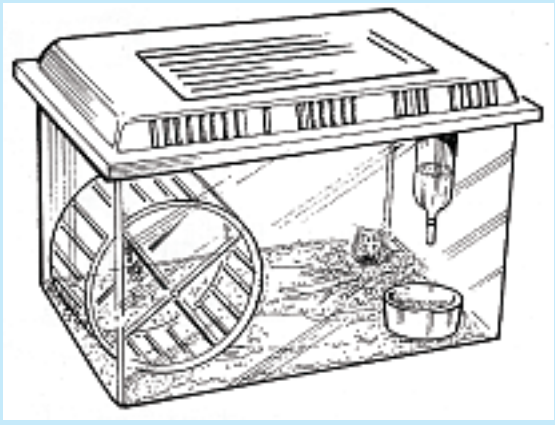
- There are layers of garden peat, sand and gravel so the gerbils can burrow.
- There is no wheel and a wheel is not suitable for gerbils as they have long tails and these can get stuck in the spokes.
- As gerbils are social animals a suitable home should have enough room for at least two animals; there are *three* gerbils in the picture.

Analysis of the discussions revealed that unless the children already kept pet gerbils they did not focus on these points. Some children wanted to choose a home that was more 'interesting' and so they opted for Home 2 (even though it is very expensive). They liked the different levels within the home as they could visualise their pet running up and down the tubes and having a different room for sleeping in. Some children preferred Home 1 because there seemed to be plenty of room for the gerbil to run around, it is plastic and therefore easy to clean and not too expensive. We found that the discussion was stimulated by the need to reach a consensus because children had to give good reasons for their choice to convince others of their preferred home. The 'evidence' they used to support their claims for a home came from the information they were given or from their own experiences; in each case the evidence was used to justify the home they wanted to buy. Analysis of the transcripts also enabled us to identify where children constructed simple arguments. For example, as this extract shows, Sheerah made the claim that she liked Home 2 (which is actually designed for hamsters) and she justified this claim in her reasoning about making the home bigger:

Sheerah: *I think that Home 2 is better because you can extend it.*

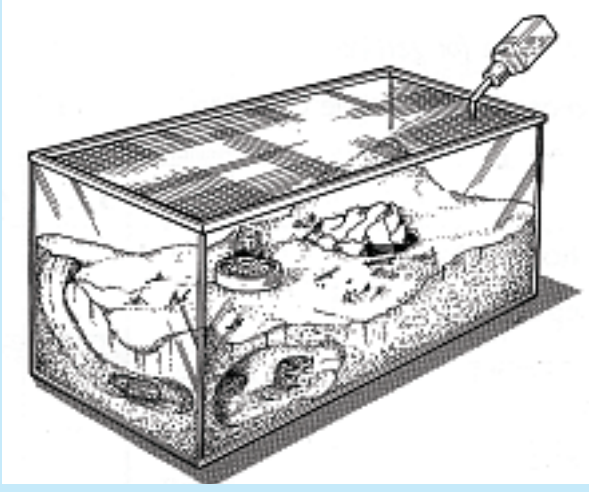
BOX 2 Activity 1: Finding a home for gerbils

This activity was adapted from a task in the *Science and Technology in Society 8–14* materials called *A home for gerbils* (SATIS, 1993). The children were given pictures and descriptions of three homes for small pets. They were asked to select one of these homes for some gerbils that they could keep in their classroom.



Home 1
This home is made for hamsters
It is made of plastic with a plastic roof
It is big enough for one gerbil
There is an exercise wheel and a plastic food bowl
It is quite expensive

Home 2
This home is made of plastic
It has lots of tubes connecting the cylinders
You can make it bigger by adding more cylinders
There is plenty of room for an exercise wheel
It is very expensive



Home 3
This home is made from an old aquarium
It is a cheap home
It has a layer of garden peat, sand and gravel
There are two rocks and a top layer of wood shavings
There is room for twigs and hay

The counter-arguments put forward by other children included that the tubes, linking the different levels in Home 2, might be too small and the gerbil would get stuck in them. Other children argued that the gerbils would like to make little burrows and so Home 3 would be better. Groups did come up with different choices but, when interviewed on an individual basis, each child could provide *reasons* for the final decisions about which home to choose. As a class activity, groups of children could be asked to present their decisions and reasons in some form, for example as a poster or orally, which would enable teachers to assess the quality of argumentation and use of evidence. Teachers would need to ensure that the children were eventually told about the most suitable home and why the other homes are not appropriate for gerbils but are fine for hamsters (see Dunphy, Holden and Ings, 1993, for details).

The design for this activity could be adapted for different contexts, for example, to provide children with details of a range of diets from which they have to choose the most suitable for an athlete, a sick child or an elderly person.

Activity 2 Bats: individual problem-solving followed by group discussion of information

This second activity focused on a decision about what should be done to solve a problem where there were many possible alternatives for the solution. The 'problem' is shown in Box 3.

BOX 3 Activity 2: What can be done about the bats?

This activity was adapted from another task in the SATIS materials, *Bats in conflict* (SATIS, 1993). The children were asked what they thought should be done about some bats that had invaded the roof of a library. The books and the library floor were being ruined. Initially, they made individual decisions. Next they were given cards that gave them information about the care and welfare of bats. The children were given time to discuss the implications of the evidence and to reconsider their decisions.

The activity supported discussion and argumentation in a different way to Activity 1; the children's alternative views were considered individually beforehand and so they all had something to bring to the discussion. Their solutions included poisoning the bats, trapping them in a box and setting them free, and abandoning the library to let the bats take over! Once they had decided upon their individual action plans they then got into groups to share their ideas and to read through the Bat Fact Cards. An example of a Bat Fact card is shown below:

BAT FACT?

It is against the law to disturb roosting bats.

TRUE

Even if they are in your own home.

As the children read the information on the cards they began to realise that they would have to change their initial ideas as any plans that involved hurting or killing the bats were unacceptable and illegal. In rejecting their original plans the children then had to devise new plans that would involve a legal way of dealing with the bats.

The activity was effective in promoting discussion because in making an individual plan all the children had ownership of an idea and a contribution to make. As the evidence cards were introduced, the children had to revise their plans to take account of the legal regulations concerning the care of bats. The children had to discuss what they would do, as a solution is not immediately obvious. This type of activity can be used for discussion and decision-making about ethical issues. Information can be introduced gradually that encourages children to constantly review their choices. The outcomes could take the form of a class debate.

Activity 3 Cups: using experimental data to make choices

This activity involved making decisions using experimental data, as shown in Box 4.

BOX 4 Activity 3: The best cup for a picnic

In this activity the children were provided with three cups, one made of thick plastic, one made of thin plastic and one made of glass. They were given data about the properties of these cups from an investigation, carried out by a group of year 6 children. The data provided information concerning the stability, the insulating properties, the mass (given as weight) and the strength of three cups (see Table 1).

They had to choose which one they would take on a picnic.

Table 1 Data on different cups for Activity 3.

Cup	*Weight*	*What happened when the cup was hit by a plasticine bob?*	*What happened to the temperature of the water?*	*What happened when a heavy book was put on the top of the cup?*
Thin plastic	3 g each	It got knocked down easily	It rose 2 °C in 5 minutes	It got squashed
Glass	250 g each	It stayed up all the time	It rose 0 °C in 5 minutes	It stayed the same
Thick plastic	10 g each	It stayed up most of the time	It rose 1 °C in 5 minutes	It stayed the same

The data set (Table 1) did not provide a conclusive answer to the problem and different groups chose different cups for a variety of reasons. Children considered who would be going on the picnic. For example, if the party consisted of only adults then glass cups would be better (that wine tastes better out of glasses than plastic cups was the opinion of some of these 10 year-old children!). However, if children were included in the picnic then the opinion was that only the thick plastic cups would do. The weather was also a consideration: if one type of cup was more insulated than the others then that would be best to keep the drinks cool in hot weather. Although cost of the cups was not included in the data some groups referred to the expense of buying glasses that could be washed and reused and buying disposable plastic glasses. They therefore drew on evidence from their own knowledge and experience.

The activity promoted discussion because the children were familiar with the context – the three types of cup and going on picnics. There was a range of views in this activity as opinions differed, for example, on whether it was better to buy cups that could be reused or, to avoid washing up, to use thin disposable cups. Clearly the choice of cup depended on the context the children devised, so a range of alternatives was considered. This type of activity can easily be adapted for many science topics. For example, children could be given tables of data about the properties of different materials used to make cooking utensils. They would then have to choose which set of saucepans to buy.

Activity 4 Marbles: discussing data with anomalous results

The fourth activity also required the children to look at data but some of the data provided were anomalous (see Box 5 for details).

BOX 5 Activity 4: Whose conclusion is correct?

For this activity the children were given different accounts of a scientific investigation carried out by four fictitious children. The investigation was designed to measure the effect of friction on the speed of a marble rolling down two different tubes. The groups were given the two tubes, one covered in bubble wrap and the other with horizontal ridges like steps down its length.

Two of the accounts included some anomalous data and it was not clear down which tube the marble had rolled faster; the two accounts reported the same results but gave opposite conclusions. The children were asked to read the accounts and decide what had happened during the investigation.

All groups recognised the anomaly in the data and some groups tackled this discussion well in trying to establish what had happened to produce the anomalous data. However, some groups did not respond well and would have benefited from teacher intervention. One group wanted to repeat the experiment so they could test which tube the marble would roll down faster. In this case, the children discussed how to carry out the experiment but they failed to consider why the anomalous results had been recorded. This was the least effective activity to encourage discussion; although all the groups recognised that the conclusions did not match the results, the children found it difficult to suggest why this had occurred. Some groups focused on the personalities of the fictitious children and suggested that '*they did not get on with each other*'; alternatively, when results and conclusions agreed,

this meant the children worked well together. It was hoped that the children would suggest ideas such as:

- The results had been copied down incorrectly and the conclusion had been based on the incorrect results.
- The conclusions had been drawn from the observations made during the investigation and the results had been added later.

The activity could be adapted to provide data from a range of investigations, each data set including some anomalous results. It could also be linked to practical work.

What makes a good discussion activity?

From the four activities, we have identified the following criteria that teachers could use when selecting or devising discussion activities that children can work on with some degree of autonomy. The activities must:

- relate to children's interests;
- provide a range of alternative choices;
- present a choice or solution that is not obvious.

Over a number of activities teachers need to find those that present information or evidence in different formats.

Assessing the quality of discussion and argumentation

The transcripts were fully coded so that patterns of talk could be discerned for each group using each of the four activities. Such 'mapping' of the data (Maloney and Simon, 2006) enabled judgements to be made about the quality of discussion and argumentation that took place in each activity, and conclusions to be drawn about the nature of collaboration that took place in the decision-making process. It became evident that the quality of argumentative discussion varied and could be summarised as a system of levels. Four main levels were identified as described in Box 6.

In comparing the ways in which the different groups of children performed, we found a great deal of variation in how they achieved different levels but no pattern emerging in relation to each activity. All the groups achieved at least level 4A in one of their activities and one group reached level 4C in all four discussions. The variations between the groups raised questions about why some groups engage in sustained argumentation using evidence whilst others may discuss the evidence but not make use of it to make reasoned arguments. We therefore looked more closely at the social dynamics of the group to see whether particular behaviours of individuals influenced the quality of discussion.

BOX 6 Level descriptions for the quality of discussion

- **Level 1. Discussion with few or no arguments**

Evidence is discussed but not used to make arguments.

- **Level 2. Series of arguments**

The children state their arguments one after the other. They take it in turns to say something. There is no discussion beforehand.

- **Level 3. Arguments with discussion**

Type 3A: The arguments are dispersed within the discussion. The discussions concern the argument but may also include story-telling related to the argument.

Type 3B: Repetitive arguments. The arguments are repeating the same points. The discussion is confirming points made, not challenging the arguments put forward.

- **Level 4. Discussion leading to arguments**

Type 4A: Discussion leads to an argument but the following discussion is not related. There is no challenge to the argument; it is just followed by a different argument.

Type 4B: Discussion leading to refined arguments. Discussion leads to an argument that engenders relevant discussion. The discussion relates to the previous argument and this leads to the reinforcement or refinement of the original argument or the development of a new argument.

Type 4C: Sustained argumentation. Discussion leads to an argument that engenders discussion and review of evidence. This leads to the reinforcement or refinement of the argument or the development of a new argument. The process of evaluating new arguments is sustained throughout the conversation.

What behaviours promote discussion?

The children were not assigned roles in the activities but we observed children taking particular actions that contributed to the success or otherwise of the discussion. Boxes 7 and 8 show the actions that do and do not promote discussion.

Where the children adopted the roles in Box 7, the group discussed most or all of the evidence made available, they gave reasons in support of their claims and requested others to justify their claims. They would consider and evaluate alternative viewpoints, and were convinced by a stronger argument should it be forthcoming. In contrast, groups of children who adopted the roles in Box 8 demonstrated lower levels of argumentation. The talk characteristic of these groups shows that they did not discuss most of the evidence, did not give reasons to support a claim or ask others to justify their claims. They did not challenge opposing views or demand evidence for claims counter to their own. When faced with evidence that supported a counterclaim they were not prepared to change their minds.

All five groups of children constructed stronger arguments in the Gerbils and the Cups activities where limited choices were given, i.e. the decision was forced by limited options. The children found it harder to construct well-supported arguments when the decision was more open-ended as, for example, in the Bats and the Marbles activities. It may be that children would find it easier to start constructing arguments in activities offering specific alternatives. Such activities need to engage children in opposition and encourage them to provide counter-arguments so that the group interacts and works collaboratively together.

The implications of this study are that if we want children to develop good argumentation and decision-making skills we need to:

- expect children to give reasons for their choices in any activity in science;
- ask children to explain why they have rejected alternative options;
- give reasons for the explanations we give to the class;
- explore how scientists had to reject their ideas in the face of new evidence.

Simple tasks that emphasise the need for cooperation but are managed by the teacher could provide a way of starting to develop children's skills of working together. Later, children can be given an agenda to guide their discussions and encourage active participation in order to make the discussions more

BOX 7 Actions that promote discussion

- Asks questions and asks others for contributions
- Makes suggestions as to what the group can do
- Starts and/or ends discussions
- Makes a final decision with or without consultation
- Directs the group; suggests what action to take
- Checks on the tasks to be done or validity of evidence
- Refers back to the evidence
- Summarises evidence
- Suggests ideas – may or may not be acceptable to others
- Makes claims with reference to data
- Responds to others by posing questions or challenging ideas
- Suggests a possible decision

BOX 8 Actions that do not promote discussion

- Does not attempt to persuade others to change their minds so the discussion is curtailed
- Has own ideas but puts them forward only when asked so may not contribute at all
- Talks about issues not related to the task and the discussion loses focus
- Tells long stories that are marginally related to the discussion
- Displays silly behaviour and distracts the others from the task

powerful. Teachers also need to develop children's cooperative skills beyond the level of 'taking turns' to speak (McWhaw *et al*., 2003). Listening to each other is not merely a matter of being quiet when another person speaks; listening requires a response to what is being said. Teachers could develop procedural guidelines to give structure to group talk so that children become used to questioning and challenging each other. The consistency in performance of one group in the study suggests that the children may have developed certain ground rules for the argumentation process, as they knew how to work together collaboratively. The inconsistent performance shown by other groups suggests that, although they were capable of high levels of argumentation, they had no such ground rules. If children are able to scaffold small-group discussions themselves then the teacher input could be directed towards children who are not yet capable of doing this.

Teachers might like to try organising the class groups in different ways to see how group composition can make the children's discussion more effective. For example, teachers could observe groups engaging in activities and see which children naturally take on particular roles. In our research we found that the most successful groups comprised children who took on the following roles. The roles are labelled according to the nature of their contribution to the discussion.

Role	*Actions*
Chair	• Started off the activity • Asked others for their ideas • Suggested possible decisions
Information manager	• Checked evidence throughout the discussion • Asked others for justification of their claims • Summarised the evidence at intervals
Promoter of ideas	• Challenged the claims being made • Suggested new ideas

In our research, the discussions were transcribed so that assessments could be made about the quality of the discussion, but such detailed analysis would not be feasible for normal classroom practice. So, if teachers want discussions to have a tangible outcome that can be assessed, the role of a Recorder might have to be allocated to the group. The Recorder would fulfil the following role:

Recorder	• Records the possible choices • Keeps a check on time • Keeps people on task

If teachers consider the ways in which children are organised in the classroom so that groups incorporate as many positive roles as possible, then they may raise children's chances of demonstrating more effective use of evidence and higher quality argumentation.

Conclusion

In this article we set out to report on the design and implementation of activities that would help to develop thinking and reasoning in science. From our previous work and current research, activities that promote such processes are those that facilitate children's talk, what Alexander (2005) terms '*the right kind of talk*', through providing good opportunities for children to discuss, argue and make decisions.

Children need to be encouraged in their argumentative interactions by having engaging activities that supply them with evidence for discussion, and teachers need to be aware of the roles that can promote good group discussion of evidence and argumentation. Our study shows how children's roles within the social dynamic of the group play an important part in the quality of argumentation and discussion that takes place.

Teachers in our research projects have often been concerned about the problems they face when trying to manage and organise small-group discussion. The research reported here attempts to show how children can work collaboratively, and to a great extent autonomously, given that the activities they are presented with are stimulating and the dynamics of working together effectively have been considered. When using such activities, teachers can take on a role that addresses individual needs and scaffolds children's learning in a targeted way.

References

Alexander, R. (2005) *Towards dialogic teaching*. York: Dialogos.

Dunphy, S., Holden, P. and Ings, R. (1993) *Animal wise*. RSPCA.

Kuhn, D. (1993) Science as argument: implications for thinking and learning scientific thinking. *Science Education*, **77**(3), 319–337.

Maloney, J. and Simon, S. (2006) Mapping children's discussions of evidence in science to assess collaboration and argumentation. *International Journal of Science Education*, **28**(15), 1817–1841.

McWhaw, K., Schnackenberg, H., Sclater, J. and Abrami, P. C. (2003) From co-operation to collaboration: helping students become collaborative learners. In *Co-operative learning: the social and intellectual outcomes of learning in groups*, ed. Gillies, R. and Ashman, A. pp. 67–86. London: Routledge.

Mercer, N., Dawes, L., Wegerif, R. and Sams, C. (2004) Reasoning as a scientist: ways of helping children to use language to learn science. *British Educational Research Journal*, **30**(3), 359–377.

Osborne, J., Erduran, S. and Simon, S. (2004) Enhancing the quality of argument in school science. *Journal of Research in Science Teaching*. **41**(10), 994–1020.

Osborne, J., Erduran, S. and Simon, S. (2006) Ideas, evidence and argument in science education. *Education in Science*, **216**, 14–15.

Osborne, J., Erduran, S., Simon, S. and Monk, M. (2001) Enhancing the quality of argument in school science. *School Science Review*, **82**(301), 63–70.

SATIS (1993) *Science and Technology in Society 8–14*. Hatfield: Association for Science Education.

Shirley Simon is a reader in education at the Institute of Education, University of London. She works on PGCE, Masters and PhD teaching programmes and has research projects on argumentation. Email: s.simon@ioe.ac.uk

Jane Maloney is a lecturer in education at the Institute of Education, University of London. She is course leader for the Secondary Science PGCE and is currently working on research in the use of puppets in school science. Email: j.maloney@ioe.ac.uk