



TEACHING PRIMARY SCIENCE: HOW RESEARCH HELPS

Wynne Harlen looks back at how research has helped shape teaching today

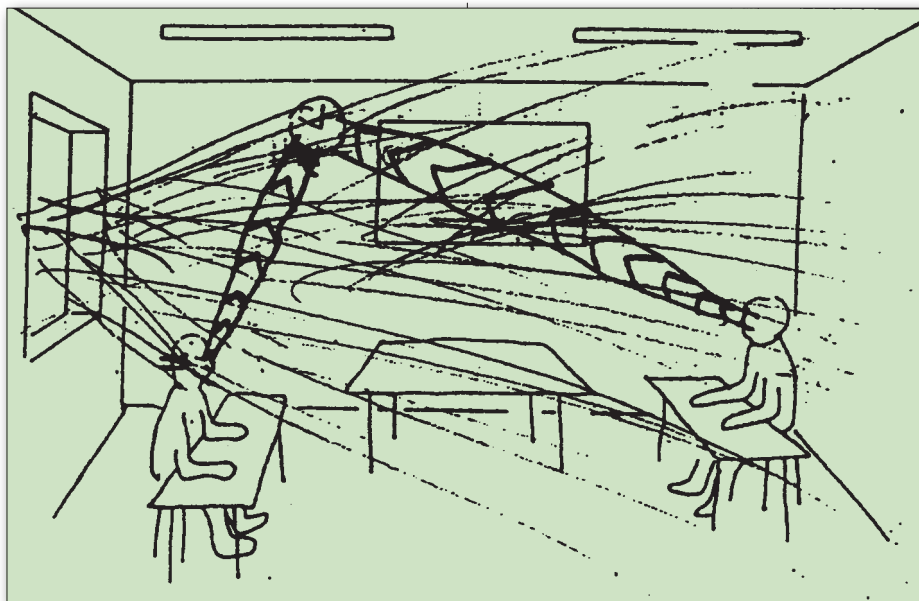
The very first edition of *Primary Science Review* included an article entitled 'Teaching primary science – how research can help' (Harlen, 1986), which announced that a section of the journal would be for reports of research and particularly for teachers reporting their classroom research. The intervening 24 years have seen momentous change in primary science in all respects. It is hard for anyone beginning in primary education in the UK today to think what it was like in 1986 – before the National Curriculum, assessment and testing. A great deal has happened, too, in relation to research in primary science education; indeed, one of the considerable influences on practice, the research on children's own ideas, was only just beginning at that time. It was closely followed by enquiries into teachers' own understanding, developing children's enquiry skills, pupil grouping, formative assessment, use of ICT, and so on – all of this prompting the change of title here to 'how research helps'. This

article looks at how research has helped to change practice in four particular areas: finding out about children's ideas; advancing their ideas; developing enquiry skills; and formative assessment.

The 1986 article urged teachers to take steps to answer questions that they raised about practice and to use the findings of researchers not just for information about what others have found, but as suggestions for changes in practice they might try out for themselves and as examples of how to study their own problems. 'Research Roundup', as it was called, continued as a regular part of *PSR* until the beginning of 1998. It is not really clear why it was not continued. One reason may have been the severe criticism being directed at much of educational research at the time, noted by Patricia Murphy in the last article in the series. She cited

criticisms of 'lack of relevance of findings to practice and the hierarchical relationship between researchers and teachers which is seen to exploit and disempower teachers' (Murphy, 1998: 26). In other words, research was not seen as serving the interests of teachers. A more optimistic view of a possible reason, however, comes from looking at the articles in *PSR*. This shows that teachers were indeed studying their own problems through careful observation and reporting innovative practices. Often they did not recognise this as research, so it was difficult for the editor to identify research articles as such. Research continues to be conducted and reported by teachers and many of the references in this article are to research by teachers that has been published in *PSR/PS* or other ASE publications.

Figure 1 An 11-year-old's drawing of how the two people in the room see the clock on the wall (Osborne *et al.*, 1990: 20)



How research helps

There are three main ways in which research can help teachers:

- through accounts of what has been systematically studied in practice and found to be useful in helping children's learning;
- by raising questions about their practice that teachers might pursue (could this help in my class?);
- by suggesting methods for classroom enquiry that can be used as part of teaching.

Such methods and ideas, if found useful, become embedded as part of regular practice; many teachers may not realise that they originated in research. Take, for example, the practice of a constructivist approach to learning and teaching, which has been widely embraced as teachers have become aware of the ideas already held by children about scientific aspects of the natural world.

How research helps in finding out children's ideas

It all began with some rather academic research into children's ideas, first in the secondary school (Osborne and Freyberg, 1985) and then in the primary school, through the Science Processes and Concept Exploration (SPACE) research project. The methods used by the SPACE researchers were to find out children's ideas, through particular forms of

questioning and analysis of children's drawings and writing as well as their oral responses. The researchers systematically recorded the ideas of a carefully selected sample of children in each class to explore their thinking about such things as what makes things move, grow, give out light, melt, dissolve, etc. (Figure 1). Meanwhile, the methods used by the researchers were adopted by teachers involved in the project and used more informally in finding out what all the children in their class were thinking about these things (see Harlen, 2007).

When teachers realise that children hold quite firm ideas about the things around them and that these ideas often conflict with the scientific view, it becomes clear that these ideas must be taken seriously. So finding out what ideas children hold becomes an important starting point. This realisation has led to the application of other research in expanding the range of ways to gain access to children's thinking. So, in addition to observing and analysing drawings and writing, teachers also began to use for this purpose:

- **concept cartoons**, which present children with a choice of scientific and non-scientific ideas, derived from research, which they discuss and say why they agree or disagree with each one (Naylor and Keogh, 2000);
- **concept mapping**, where children show diagrammatically the relationship between words

used in a particular topic (Cross, 1992);

- **digital photography** to record and display particular events during children's activities as a basis for discussion (Lias and Thomas, 2003).

How research helps in advancing children's ideas

Even though their ideas are incomplete or 'unscientific' children have good reasons for holding them, based on their necessarily limited

reasoning and experience.

Sweeping them aside and attempting to replace them with the 'correct' view is only going to lead to confusion. So finding their ideas is only a first step in using a constructivist approach; the important further step is to do something to help children consider and try out a more scientific explanation. Testing their own idea by using it to make a prediction is a good way of enabling children to consider alternative explanations. However, without any feasible alternatives available, children tend to adjust their non-scientific ideas to accommodate challenging evidence (Box 1). So, how do we introduce alternative and more scientific ideas without imposing what is 'right' over children's 'wrong' thinking? Here, research into group work and promotion of dialogue and argumentation make a combined contribution.

Group work affords opportunities for discussion of ideas, but how productive this is depends on the composition of the group and how the teacher manages discussions. Researchers identify different forms of discussion: dialogue and argumentation:

- **Dialogue** describes exchanges where there is symmetry in the parts played by those involved: all, including the teacher, ask and answer questions, talk and listen, reflect and consider what they say, treat mistakes and differences

as learning opportunities, and respect differences of opinion.

● **Argumentation** shares these qualities but with added emphasis on evidence to support claims or ideas put forward.

Both dialogue and argumentation can take place in a whole-class or group setting, but in group work, in the absence of the teacher, children are dependent on their own thinking and use of evidence. They hear other ideas and realise that their own idea is not the only way of looking at things – an essential step towards considering more scientific explanations.

Not all groups are productive in this respect. Research into group composition has shown that groups made up of children with different initial ideas make more progress than groups where children have similar ideas (Howe, 1990). Groups do not automatically operate collaboratively; it is generally necessary to give guidance and practice in listening, questioning and giving explanations to others. Research (Howe *et al.*, 2007) shows that this pays off in terms of better conceptual understanding.

How research helps in developing enquiry skills

The way in which children try out their ideas, through predicting, planning, collecting information and interpreting what is found, clearly influences how they explain their observations or answer their question. In the Science Teacher Action Research (STAR) project, teachers and researchers started by making observations in classrooms and feeding back to teachers the evidence – to the surprise of some – that children were capable of using these skills (Cavendish *et al.*, 1990). Teachers then began to find ways of improving their children's skills and shared what they found with other teachers. To help with their action research, the teachers were provided with ways of assessing the change in children's skills (Schilling *et al.*, 1990).

This work coincided with the introduction of the National Curriculum and the requirement

for teachers' assessment of skills as well as knowledge and understanding. Some of the research on the value of enquiry skills found its way into the curriculum in the form of what became known as Sc1. Other research, from the AKSIS (ASE and King's College Science Investigations in Schools) project, helped teachers with the problems revealed by classroom observations (Feasey, 2006).

In the subsequent decade some of the main research-based developments were concerned with assessment, particularly formative assessment.

How research helps in developing formative assessment

One of the consequences of the criticisms of education research in the late 1990s was the recognition that not all educational research was of high quality. Greater attention was given to conducting reviews, combining the results of relevant research studies, in which the quality of the research was a factor taken into account. The review carried out by Black and Wiliam into classroom assessment (Black and Wiliam, 1998) opened up opportunities for raising standards by using assessment to help teaching. It

revealed evidence that change in practice in relation to selection of tasks, feedback, self-assessment and teacher–pupil interactions can improve learning. But the researchers did not have the answer to how to implement these changes in the classroom. For that they worked with teachers who tried out ways of implementing the general principles in their classrooms. Although developed in lower secondary school classes, the implications for primary schools have been brought together in one of the Black Box publications (Harrison and Howard, 2009).

In conclusion – does research help?

Only a fraction of the research activity in the last 24 years has been mentioned here, but I think it serves to show how practice in primary science has been influenced by research, mostly involving collaboration between researchers and teachers. It is often said, and is still no doubt true, that those involved in the development of new ideas and practices benefit most. Not all can be involved in projects, but by sharing what has been done, through the pages of *PS* for example, others can try it in their classrooms.

Box 1

Some ideas are hard to change (from Harlen, 2000)



The idea of the eye being active in seeing, rather than a receiver of light coming into it, is widely held even by secondary-age pupils ... Children will hold on to this

idea, despite the question that it

raises of why, if the eye is active, we are not able to see in the dark. The answer given by one 10-year-old was '*With no light your eyes cannot see anything. As soon as you turn on the light your eyes can see again. Your eyes sort of work like a light; when there's no light you can't see but when there is light you can see.*'

Educational research, as I suggested in *PSR 1* (Harlen, 1986: 20), is:

systematic activity that is carried out for the purpose of providing knowledge, or adding to the understanding of existing knowledge, which is of relevance to improving education.

It includes enquiry and reflection, through which findings from studies can be adapted by teachers to the particularities of their own classrooms.

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Wynne Harlen was editor of *Primary Science Review* from 1999 to 2004, a member of the ASE Research Committee from 2004 to 2010 and President of ASE in 2009.

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