Scientific Reasoning

We need to get some dots!

CHRIS JOYCE, ROSEMARY HIPKINS AND CARLA MACLEOD DESCRIBE PRACTICAL STRATEGIES THAT SUPPORT YOUNG CHILDREN'S ABILITY TO REASON DURING FAIR TESTING

Hands-on science is fun, but it can be challenging for teachers to 'switch minds on' and still retain children's natural enthusiasm for investigating. Here we describe how two researchers and a classroom teacher worked together to try out two simple strategies to help young children develop their reasoning skills. The context used is fair testing. One strategy helps children to plan and set up a fair test, while the other helps them compare the results of multiple trials.

Developing the strategies

Experience tells us that children are not always able to discuss controlling variables and they often forget the process involved when setting up a fair test. A search of the literature confirmed that young children do not have the memory span to hold in their heads all the information required. To provide opportunities for children to develop the ability to control variables, and to keep track of them when conducting a fair test, we devised some strategies that could support the development of their reasoning skills in fair testing. These involved:

- reducing the demand on their memories by displaying more of the overall investigation simultaneously;
- making the effects of 'unfair' management of variables more immediately obvious, so children could reason out any changes they might need to make as they proceeded;
- making data-recording quick and easy, so repeats were manageable and engaging;
- making patterns of results obvious so that comparing and reasoning about them was easier.

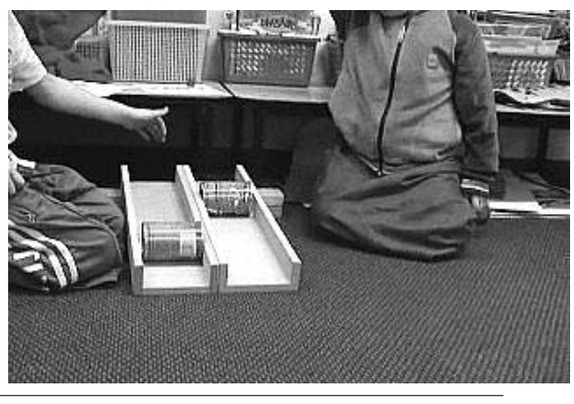
The strategies

Matched pairs of equipment and planning cards

We got this idea from the research of Toth, Klahr and Chen (2000). The strategy involves setting up two side-by-side sets of equipment (e.g. Figure 1). Any changes made to one set are then obvious to children. The strategy supports children's ability to recognise fair tests by simultaneously showing the whole experimental situation.

A variation on this strategy involves the use of a series of cards that show the same situation in different variable combinations. From amongst all the cards available to them, children select a pair that would create a fair test for a specific question. Selection of a pair of cards allows children to check, using the simplified visual cues, that only one aspect is different. Individual cards can be manipulated into various trial combinations, making the strategy ideal for small-group discussion. Again, the cards support children in recognising a fair test, rather than having to think of and remember all the variables. Once they have chosen the right cards, they set up their equipment using the cards as a model.

Figure 1 **Matched pairs of equipment support fair testing**



Using coloured dots to compare results of multiple trials

An important part of data collection is being able to look at the patterns and trends and think about what they might be telling us about the investigation. However, measuring accurately is difficult for young children. As well as this, trying to remember or note down all the measurements is a barrier to young children being able to see patterns, let alone think about what the results might mean.

Using coloured sticky dots to record measurements provides a visual prompt. We first trialled this with another small group of children, to capture the results of a series of test runs of small cars on a ramp (Hipkins and Kenneally, 2003). A large strip of brown parcel paper was used as the landing surface. Coloured dot stickers were used to mark the results of each run. This allowed the trials to be completed in rapid succession and showed the variability that happens even if nothing appears to have changed. Two colours of dots were then used to compare tests after one variable was changed (Figure 2).

Figure 2 **Use of coloured dots for recording and comparing results**

Using these strategies with young children

We worked with Carla, who was teaching at a small inner city school. The children in her class ranged from ages 5 to 7. We were particularly interested in whether very young children could independently apply fair testing in their investigations if the control of variables was simplified. We were also interested in whether they could then use their data to think about friction.

Together we planned a series of four lessons to develop the children's expertise in fair testing in the context of rolling objects. Examples of some of the questions the children investigated are:

- *Which will roll further, a big marble or a small marble?*
- *Will a marble roll further on a smooth surface or a carpeted surface?*
- *Which will roll further, a jar of water or a jar of cotton wool?*
- *Which will roll further, a tin of cat food or a tin of soup?*

Below, Carla briefly describes how the strategies were used in her classroom.

I began by modelling fair testing and asking questions before the children worked in groups of three to carry out their own fair test.

An important part of each session was the pre- and post-activity class discussions, during which rich questioning encouraged the children to share their ideas. Planning these questions before the teaching sessions helped me focus my questioning on key points.

For the first lesson I showed the two ramps to be used to roll the marbles down. One ramp was smooth and the other had carpet on it. The children were introduced to the idea of variables that could be changed. The discussion questions were:

- *What do we need to change?* (the surfaces)
- *What do we need to keep the same?* (the size of the marble, the slope of the ramp, the starting point for letting go)

To set up the investigation, the key question was:

- *What are we going to measure?* (how far the marble rolls)

The children then made a prediction:

I predict the marble on the smooth/carpet ramp will roll further because...

I also modelled the use of coloured sticky dots to record the distance marbles rolled on different surfaces. They enjoyed using sticky dots and it was a lot easier for them than using rulers and pencil and paper.

The sticky dots meant that the results of the investigation were easy to see. The dots provided a chart that led into the concluding discussion. Appropriate questions provided the key for effective post-activity discussion for children to consider the variation of the results:

- *Why did we need to roll each marble ten times?*
- *What do you notice about the pattern of dots?*
- *What does that tell you about our question?*
- *What is it about the surfaces that might make this happen?*

Key questions kept the class discussion focused around fair testing and prompted the children to share their thinking about the science concept being investigated (friction).

In the last two sessions the children worked in groups of three to set up their own fair tests. The floor in the classroom had only one surface (carpet), so we had made up sets of ramps, some left as smooth wood and some covered in carpet. Before they began, I gave each group a set of cards to discuss. Because of the age of the children we had further simplified the paired-card strategy by providing already matched pairs from which they chose the card pair that was 'fair'.

Figure 3 shows the cards that we made to support children as they devised a plan to use the pairs of ramps shown in Figure 1.

What we found out about the strategies

Paired cards and paired equipment

We found that when using the cards even young children were able to identify a fair test and replicate the set-up of the equipment for their investigation. The conversations within the groups as they carried out their tests were peppered with many references to what might or might not be fair, and the choices they needed to make. Here are two

specific examples of ways in which the materials supported two 7-year-olds in the class as they used their reasoning skills:

- One boy displayed a clear understanding of variables. His group's chosen card pair showed both ramps with carpet, but he chose two smooth ramps. When asked about this, he conceded that this was different from the card, and then said, '*But it doesn't matter because they are still both the same*'.
- One girl used the structured material to '*be the teacher*'. She invited choices from the card pairs as she coached the younger group members in making fair decisions. As she did so, her reasoning skills were very evident.

Recording measurements with dots

This strategy was very successful as it meant that data could be recorded quickly and easily, and repeats were manageable and engaging.

The children enthusiastically picked up this strategy the next day, when they were carrying out investigations independent of the teacher. A 5-year-old from one group was heard to announce, '*We need to get some dots*'. Recording measurements by placing a coloured dot where each object stopped had two advantages. Inaccurate measuring was eliminated, and comparing the two sets of coloured dots gave the children visual evidence of which objects consistently rolled further.

We do, though, sound a note of caution. Some children began to speak of individual runs as 'winning' runs when the rolled object went further, as if each trial was of a separate object rather than a repeat rolling of the same object. Carla had not talked to the children about why there might be variations in the data collected from individual trials, although they at times commented in their groups about objects '*getting stuck*' or being '*pushed*' as they let them go. Directing children's attention to the overall pattern introduces the idea that tests need to be repeated so we get a picture of the inevitable variability in repeated trials, and that we need to look at the pattern to interpret the data, not just the marble that went furthest.

Conclusion: the value of visual cues

We found that the visual cues provided by the structured materials made the reasoning challenges less abstract. Once the children were less reliant on holding sequences in their memory, reasoning about fair testing was more accessible and they were able to demonstrate and discuss their thinking. The teacher's role in modelling strategies and thinking out loud was central to the success of the strategies. Carla provided opportunities for children to complete their own investigations, and asked questions that encouraged and challenged them to think for themselves.

These activities took place very near the end of a school term, when there were all sorts of exciting distractions in nearby classes. Yet the activity and enthusiasm of the children was sustained throughout. Some even got the ramps out in their own time, to test and play some more. We managed to achieve the informal, exciting, spontaneous buzz of young scientists at work, while at the same time supporting them to make reasoned judgements about their investigations. We think this is a very worthwhile type of science experience for all young children.

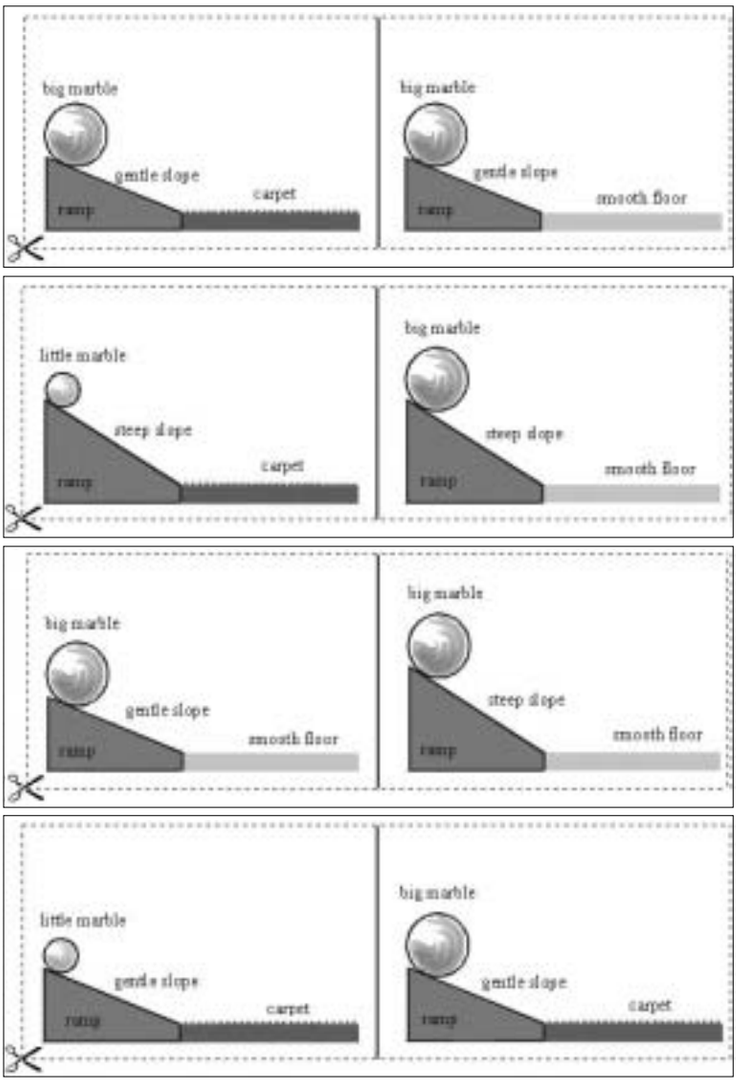


Figure 3 **Using cards for selecting a fair test**

References

Hipkins, R. and Kenneally, N. (2003) *Using NEMP to inform the teaching of scientific skills*. Wellington, NZ: New Zealand Council for Educational Research. Available at www.nzcer.org.nz

Toth, E., Klahr, D. and Chen, Z. (2000) Bridging research and practice: a cognitively based classroom intervention for teaching experimentation skills to elementary school children. *Cognition and Instruction*, 18(4), 423–459.

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