thinking & feeling

ATOMS AND MOLECULES

do they have a place in primary science?

Kam-Wah Lucille Lee and Swee-Ngin Tan believe that a particle approach to explaining some everyday phenomena can enhance children's conceptual understanding in science

In primary science, topics such as matter, air, water and changes of state are generally introduced through hands-on activities using everyday resources. Many children find it difficult to understand basic science concepts such as states of matter (solids, liquids and gases) and everyday phenomena such as evaporating and dissolving. Their understanding can be influenced by the things they use in everyday life or by 'everyday' usage of words. For instance, they consider solids as hard and rigid and have difficulty classifying soft, malleable and granular solids. They think liquids are 'runny', so viscous liquids cause conceptual difficulty. Many tend to associate gases with gas cookers. The literature has reported that children see matter such as flour as continuous and do not realise that matter is made up of particles. They will draw a block for solids, a partially filled container for a liquid, and wavy lines to represent a gas.

What research tells us

Some Greek research

Hatzinikita and Koulaidis (1997) explored children's ideas about conservation during changes in the physical state of water. They administered a questionnaire to a large sample (4297) of primary and secondary school children in Greece. The questionnaire consisted of seven items on children's ideas on evaporation, boiling, condensation and conservation of mass. In responding to the items about 'drying of water in a dish' and 'drying of laundry', about 20% of the 10–11 year-olds thought that the water had 'disappeared' or been 'absorbed by the dish'. Less than 20% of the 13–18 year-olds thought that water was transformed into gases rather than being 'absorbed' or 'disappearing' during the drying process. When asked about the composition of bubbles in boiling water, around 20% of 10–13 year-olds thought that 'bubbles consist of heat', while about 25% of 14–18 year-olds thought that 'bubbles consist of hydrogen and/or oxygen'.

SPACE research

In one of the Science Processes and Concept Exploration (SPACE) projects, Russell and Watt (1990) conducted a classroom-based study of 5–11 year-olds' ideas on evaporation and condensation. The teacher researchers used everyday phenomena such as 'dropping water level in a large container of water over a period of time' and 'breathing out in cold air or against a cold window' to investigate their pupils' concepts of evaporation and condensation.

Questions asked included *'Where has the water gone?'*, *'What has made the water go?'* and *'Can the water be made to go faster/slower?'* Examples of the pupils' responses are given in Box 1.

Findings from Australia

The Australian Council for Educational Research (ACER) study conducted by Adams, Doig and Rosier (1991) found that very few grade 5 pupils appeared to use the particle model to explain differences between states of matter, or processes such as evaporation, condensation or chemical change. Nevertheless, some of these pupils seemed to believe that many chemical and physical changes could be explained by referring to the non-observable. Recent research (e.g. Johnson, 1998) indicates that understanding the structure of matter in terms of particles, such as atoms and molecules, can enhance pupils' conceptual understanding of the properties of matter and some chemical phenomena.

Building on these findings

These results seem to show that the understanding most primary-age children have of the structure of matter does not intuitively relate to its particulate nature. They tend to interpret the chemical world using some naive ideas, though some use abstract ideas.

A few educators (Leisten, 1995; Skamp, 1998) have argued that particle ideas should be introduced gradually by building on children's naive questions about matter, and by the accumulation of examples and specific instances of the behaviour of matter. For example, when upper primary children study the concepts of evaporation and condensation, they might be introduced to the particulate explanation on how the water changes from one state to another. Whether some upper primary children could start to appreciate some of the properties of chemicals in terms of their particle nature is an area in which teachers should tread carefully. Could the particle model of matter be the underlying 'big idea' in a primary science teacher's mind as he or she interacts with children on the relevant topics? Depending upon the specific content and context and the age of the children, some teachers may find it appropriate to help them think of the world in terms of particles.

Box 1 **Pupils' explanations for evaporation and condensation**

Dropping water level in a water tank over a period of time

'I think the water will evaporate up into a cloud and then burst again.' (age 10)

'I think the air goes in the water dries it up and pulls the water up into air.' (age 8)

'When the water evaporates it goes on a cloud then the cloud goes in any place and later it go out as rain. It will keep going until it is all gone and then it will go to another place with water and do the same. The cloud is like a magnet so the water goes through the cracks and goes up, that is what I think.' (age 10)

'I think the water has split up into millions of micro bits and floated up and it floats out of the doors or windows when they are opened.' (age 10)

Breathing out in cold air or against a cold window

'We breathed on the window and it all soaked up. I think it is cold. I think it comes from my mouth. I think it gone into the air.' (age 9)

'I can feel hot air coming out of my mouth and it looks like steam or smoke but when you touch it, it does not feel like anything but heat. It also looks like mist or a foggy day. I can only see it when it's cold.' (age 10)

(Russell and Watt, 1990)

Using the particle model – two examples

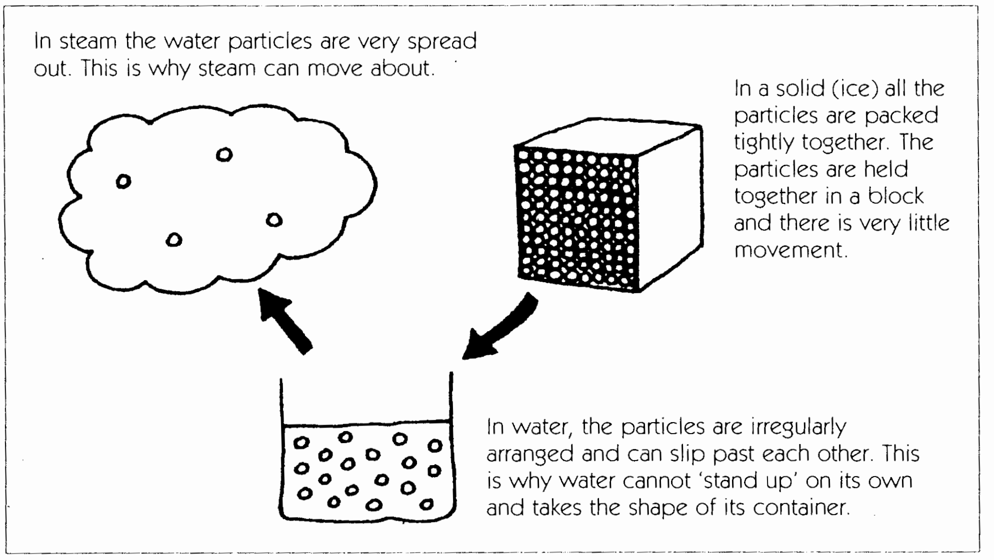
Water

Water is made up of many water molecules, each containing two hydrogen atoms and one oxygen atom combined together chemically. Using a circle (o) to represent a water molecule, the different arrangements of water molecules in ice, liquid water and water vapour can be used to explain the different physical properties of water in the three states (Box 2). For further details of the particulate structure of water in terms of atoms and its unusual properties (e.g. ice is less dense than liquid water, whereas for most substances the solid state is more dense than the liquid), see Segal (1989, pp. 162–165).

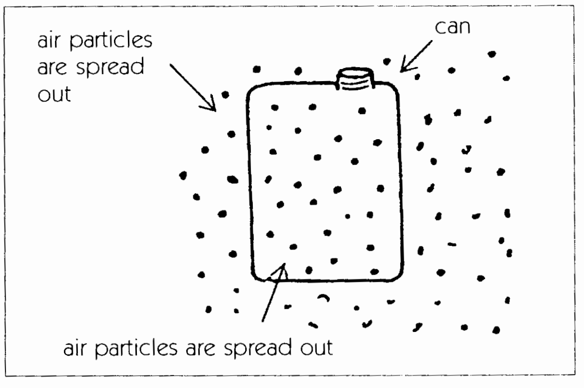
Air

Air is made up of particles. Box 3 shows how the air particles are arranged inside and outside a can. Children are asked questions, such as *'What happens when some of the air in the can is removed?'*, *'Does the mass of the can remain the same after some air is removed?'*, and so on. They are encouraged to use particle model ideas to explain their answers. Box 4 shows two possible particulate diagrams of the air inside the can after some air has been removed. Only one of them is scientifically acceptable.

Box 2 **Particulate representation of the three states of water**



Box 3 **Air inside and outside a can**

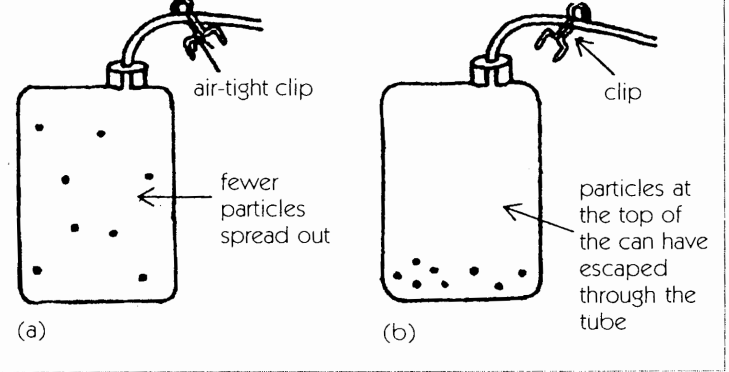


Conclusion

Teachers may consider using the particle model to enhance conceptual understanding of phenomena observed in everyday life or encountered in hands-on activities. The teacher needs to decide when this approach is appropriate, in terms of content, context and the ability of the children. Audio-visual aids (e.g. models, analogies, simulations) may be useful to supplement drawings of particles. Dynamic graphical presentation of change of state is effective in demonstrating the movement of particles and the attraction forces between particles. Explanation of some everyday phenomena or observations, for example dissolving, diffusion of perfume, movement of smoke, spread of powder or flowing water, in terms of particles can enhance children's conceptual understanding in science.

Box 4 **Air in the can after some of the air is removed**

Which diagram, (a) or (b), do you think correctly represents the particles of air after some air has been removed?



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