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USING POE SEQUENCES

POE sequences provide an important way to enhance your students' understanding of key scientific ideas. We believe that POE sequences are an invaluable tool in every science teacher's repertoire, as the sequences can both enliven science instruction and provide a firm basis for understanding. POEs are based on a sound theoretical foundation that has been researched extensively.

Children live in a world of sense impressions. They see, hear, smell, touch and taste. From infancy they spontaneously make sense of the world in which they live. They form concepts and try to link one concept with another to explain the world around them. For example, they might come to think that matter disappears when substances dissolve or burn, or that plants take in food through their roots, or that heavy objects such as stones or nails sink, or that heavy objects fall more quickly than lighter ones. They find such ideas useful in their lives. The idea that children – or all of us, for that matter – construct such understandings of the world is fundamental to the constructivist view of learning.

Scientists also try to make sense of the natural world of sense perceptions. This is their collective mission. They do this deliberately and carefully. They extend our sensory world by using instruments to measure mass, length and time more accurately. They use instruments to measure the large and the small, the hot and the cold, the soft and the loud and so on, in order to enhance our sensitivity. They expand the natural world by carrying out experiments, enabling them to observe phenomena that do not occur naturally. They formulate concepts such as density and gravitational force and arrive at powerful generalisations, such as that an object floats when its density is less than that of the liquid in which it is immersed, or that the acceleration of all falling objects is the same in a vacuum.

There are thus two types of interpretations of the world in which we live: everyday, commonsense interpretations and those of the community of scientists. It is part of a science teacher's job to help each student build on everyday, commonsense interpretations so that the student can adopt and internalise scientists' interpretations. This can be a very challenging task, especially when the scientific interpretation is at odds with students' interpretations. For example, some students believe that electricity gets used up as it goes around a circuit, or that vacuums suck. These ideas have worked well for the students concerned. So why should they change their ideas now?

How can the science teacher respond to this challenge? A variety of teaching strategies have been developed to complement the constructivist view of learning. As you would expect, they have many features in common. The POE sequences we have developed embrace many of these features, and they are incorporated into the steps for using POEs on the following pages.

CORRELATIONS TO THE

AUSTRALIAN CURRICULUM: SCIENCE

Science provides an empirical way of answering interesting and important questions about the biological, physical and technological world. The knowledge it produces has proved to be a reliable basis for action in our personal, social and economic lives. Science is a dynamic, collaborative and creative human endeavour arising from our desire to make sense of our world through exploring the unknown, investigating universal mysteries, making predictions and solving problems.

—ACARA, Australian Curriculum: Science, http://www.australiancurriculum.edu.au/science/rationale

The recent publication and ongoing implementation of the first national Australian Curriculum: Science for Years F–10 offers an excellent opportunity for primary and secondary teachers across Australia to ensure that their students are receiving targeted science instruction that imparts the core knowledge, understandings and skills needed to equip them for their future lives and careers. Since each chapter of *Predict, Observe, Explain* focuses on a different key area of science knowledge, and because the activities it includes can be adapted for use in a variety of different levels – as introductions to a topic, as revision activities or as a way to gauge student learning – this book is an invaluable resource for teaching scientific ideas in alignment with the new curriculum.

To aid teachers in matching their POE-based lessons to specific curriculum content descriptions, this revised Australian edition of *Predict, Observe, Explain* contains a scope and sequence chart that displays how each chapter correlates to a learning progression in the Science Understanding strand of the Australian Curriculum: Science. Chapters 1–6 are shown on pages 10–11, Chapters 7–11 are on pages 12–13, and Chapters 12–15 are mapped on pages 14–15.

Although the POE activity sequences in this book are targeted towards upper primary and secondary students, they could easily be simplified to suit younger children as well. For this reason, the scope and sequence chart includes content descriptions at each year level of the Science Understanding strand, from Foundation to Year 10.

Scientific Explanation

The answer to both introductory questions is true.

(i) The air in a tennis ball tries to expand as it heats up. This affects the bounce.
(ii) As you drive, your tyres heat up on account of friction. The air tries to expand. The pressure inside the tyre rises.

Air expands when it is heated. The balloon inflates a little when the bottle is put in warm water. It inflates more when the bottle is put in hot water. Dr Y's invention helps you see this expansion clearly. The glass tube records small changes in volume. Dr Y's invention can be turned into a thermometer by calibrating it.

Students' Explanations: Field Experience

This POE was used with Year 7 students. A sample of 25 responses was analysed. Ninety-six per cent (96%) predicted correctly that the balloon would increase in size. The teacher remarked, "High success rate – some students felt it was much too easy." However, a close examination of their responses indicated that only 60–70% seemed to directly relate the expansion of air to temperature increase. Some of these students expressed themselves succinctly, some did not. Compare these two examples:

The air will expand and fill the balloon because it cannot escape.

I think the balloon will blow up because the hot air pressure will make the balloon expand making it blow up.

Among the remainder, a variety of scientifically unacceptable reasons for their predictions was evident:

Because heat rises so that it will blow up the balloon.

The air will turn into steam.

I think the vapour will blow up the balloon. The vapour has to go up so it will go into the balloon.

... the water will expand and force air into the balloon.

Forty per cent (40%) of students made valuable suggestions for improving Dr Y's temperature measurer, 24% suggested putting a scale on the glass tubing, and 16% talked in terms of calibrating the tube.

This student even gave details of how he would calibrate the tube:

I would put it in freezing water to make the water go to zero and make a mark, then put it in boiling water and make a mark, then divide the rest of the middle up.

Students' Explanations: Research Findings

In his study of 25 8- to 11-year-olds (reported in Driver, Squires, Rushworth and Wood-Robinson 1995), Appleton found that many lacked knowledge of how thermometers worked, possibly related to them seeing heat as a "substance" (see De Berg 2008) rather than in relation to the *thermal motion* of particles. When students understand that heat represents the thermal motion of particles, then they have improved understanding of the contraction and expansion of materials when heated or cooled (Ebenezer and Puvirajah 2005).

Equipment and Materials

- soft drink bottle (glass works best)
- balloon
- bucket

Dr Y's invention: 1 hole stopper, small flask or bottle (about 100 ml), 1 m of glass tubing (if desired, this can be bent in a propane flame), rubber tubing

Scientific Explanation

As the flask cools down, the steam condenses and leaves less and less water vapour in its atmosphere (at room temperature there is almost a vacuum in the flask).

As the flask cools down, the sound of the bell decreases. If you listen carefully, you can just hear it at room temperature.

Sound is audible vibration. Vibration cannot pass through a vacuum because there is nothing there to vibrate.

Students' Explanations: Research Findings

Researchers have found that although younger children readily associate sound with an object vibrating, they less readily perceive that air or another medium is required to transmit these vibrations. By age 16, however, three-quarters of students appear to understand that air is needed (Asoko, Leach and Scott 1991).

Equipment and Materials

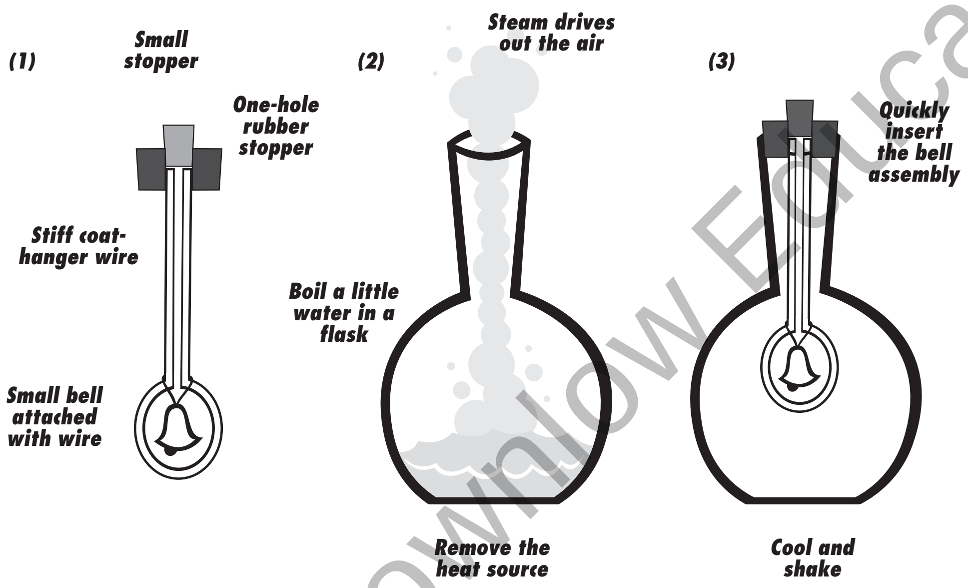
- flask
- 1-hole stopper with small stopper to fit
- length of copper wire
- small bell

Air to Hear?

Riddle

You need air to breathe, but do you need air to hear? There's no air on the moon – could you hear anything there?

An Experiment



Predict

Will you be able to hear the bell? Tick one [√]. Yes **[ ]** No **[ ]**

Please give your reasons. ______________________________

____

Observe

Let's do it! What happens? ______________________________

____

Explain

Can you explain your observations? ______________________________

____

More to Explore

What do you think will happen if you remove the small stopper and allow air to enter the flask? Try to explain your answer.

____

Scientific Explanation

The chemical reaction between copper chloride solution and aluminium is an interesting one. The blue-green solution loses its colour and a brown sludge – copper – forms at the bottom of the beaker. There is no change in mass.

copper chloride (solution) + aluminium → aluminium chloride + copper

In the follow-up example, the sodium carbonate reacts with the copper chloride to form copper carbonate (blue solid) and sodium chloride, dissolved in water.

sodium carbonate (solution) + copper chloride (solution) →
copper carbonate (solid) + sodium chloride (solution)

Although there is a chemical change (or exchange), nothing is lost. The mass remains the same. The law of conservation of mass states that for chemical reactions "mass can neither be created nor destroyed."

Students' Explanations: Research Findings

Briggs and Holding (reported in Driver et al. 1994) found that 75% of the secondary students they studied considered apparent change of mass as evidence of chemical change.

In their publication, which potentially has great significance for chemistry teachers, Horton and his colleagues (Horton 2004) identified more than 150 studies of students' alternative conceptions in chemistry. They then proceeded to categorise these by concept. Here are some of the alternative conceptions they included under the concept of conservation of matter in reactions:

(a) A large proportion of 12- to 18-year-olds do not think mass is conserved.

(b) Mass is lost in combustion.

(c) When steel wool burns inside a closed flask, its mass changes. When steel wool burns in the open, its mass decreases.

(d) A rusting nail loses weight. A rusting nail won't change weight. Some students thought that the rust was already inside the nail, and some thought that it had only reacted with oxygen in the air, which weighs nothing.

(e) A precipitation reaction results in change of mass; the mass increases because solids weigh more than liquids.

Equipment and Materials

- copper chloride solution
- aluminium foil
- masses
- balance
- sodium carbonate solution

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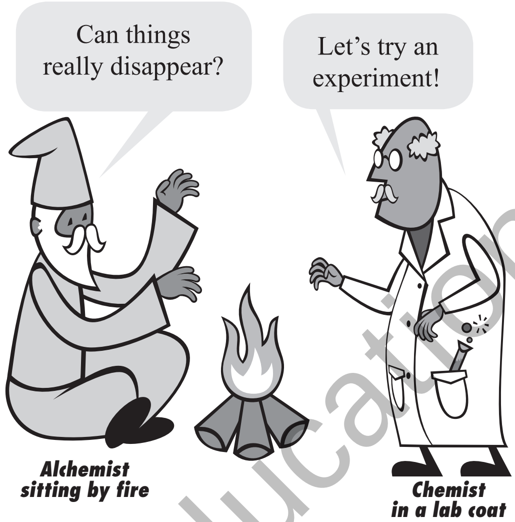
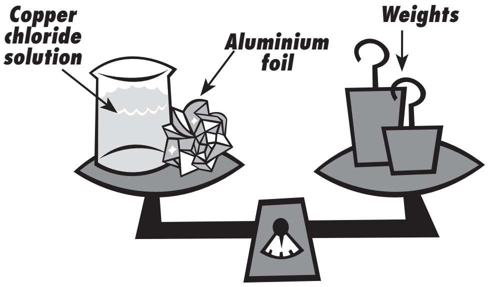
Can Things Really Disappear?



If an Alchemist Could Meet a Chemist

The early chemists – the alchemists – were fascinated by chemical change. It must have seemed like magic to them – things changing, things appearing and disappearing. They must have wondered, "Can things really disappear?"

Chemists today would be able to answer most of their questions. They might say, "Let's try an experiment!"



An Experiment

Aluminium foil and copper chloride solution react chemically.

Do you think the mass will change when the aluminium foil is put into the copper chloride solution?

Predict

Tick one [√]: Mass increases. [ ] Mass decreases. [ ] Mass stays the same. [ ]

Try to explain your thinking for your prediction.

____

____

Observe

Let's do it! What are your results?______________________________

Explain

Try to explain what happened. ______________________________

____

More to Explore

Try mixing a solution of sodium carbonate (washing powder) with the copper chloride solution.

Do you think the mass will change? ______________________________

Try it! What happened to the scale? ______________________________

Why? ____

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