Let's turn things on their head

– teaching counterintuitive science

David Kumar *explores how tackling concepts from an alternative perspective might enhance learning*

Figure 1 The inverted cup is a popular counterintuitive demonstration

Teaching science through counterintuitive events is an effective way of engaging students in exploring science; such events motivate and involve students in solving problems with a high degree of creativity and critical thinking. This can push students into a seeking explanation mode, setting the stage for discovery.

For example, half fill a clear plastic cup with water and, holding the cup with one hand and an index card against the mouth of the cup with the other, quickly invert the cup along with the index card and then remove the hand holding the card. Counterintuitively, the water remains inside the cup and the index card remains covering the mouth of the cup (Figure 1).

What makes an event counterintuitive?

An event is counterintuitive if the presentation of a phenomenon runs counter to what a person intuitively thinks is likely to happen (Hofwolt, Kumar, Johnson, Carrison and Altman, 1992–93; McCrory, 2013; Wright, 1981). An event is counterintuitive only if the event is slightly mismatched from the viewer's current cognitive structures or experiences.

To children, an event or discovery that goes against what they intuitively believe should happen appears to be 'magic' and their curiosity is triggered. The fact that the behaviour of the phenomenon differs from expectation indicates that critical experiences allow the student to recognise that something is 'wrong', leading to a heightened level of curiosity. Since curiosity is heightened by counterintuitive events, intense student involvement can be utilised to resolve this discrepancy. The objective might be focused on arriving at a satisfactory explanation of the phenomenon, whereby students might be encouraged to perform additional investigations, read resource materials, use clues to seek additional information, collect data, and apply prior knowledge to explain the observed phenomenon (Kumar, 2010). Activities such as guided discovery can follow. Because of their attention-grabbing capacity, counterintuitive events can be used to initiate a wide variety of classroom activities. Part of the process of arriving at a solution may involve asking three questions: What do we know about this event? What do we need to find out? How can we use this information? Because of a vast experience base, many events that amaze children are not counterintuitive to adults. Easily carried out counterintuitive demonstrations, suitable for the primary age phase (5–11) are described below.

Key words: Practical activities, Challenging thinking

Examples of counterintuitive science activities

These activities (see further reading below for the sources) are easy to carry out with inexpensive household or locally bought materials.

Safety: The activities require adult supervision, safety goggles, and observation of all laboratory safety rules and procedures. See *Be safe!* (ASE, 2011) for much useful safety advice.

- A beaker of alcohol, a beaker of water, and a beaker of an alcohol and water mixture are placed side by side. An ice cube is placed in each of the three beakers. The ice floats, sinks, and is partially suspended in the three beakers.
- A paper cup (non-waxed) is half filled with water and is heated by a candle placed under it. Although the flame of the candle is directly below the cup, the cup does not burn.
- Place a piece of paper under a paperweight, and pull the paper out quickly. The paperweight doesn't move.
- Place a needle very gently in water. It floats.
- Mix 50 ml of alcohol and 50 ml of water in a 100 ml graduated cylinder. The sum of the two liquids together is less than the 100 ml.
- Place an ice cube on an inverted beaker and stretch a thin wire over it with heavy weights attached to the wire on each end. The wire will cut through the ice cube, but the path the wire takes in cutting through the ice cube freezes behind the wire leaving the ice cube intact.

Figure 2 How many water droplets can you heap on to a penny?

- Place a penny coin flat on a paper towel on a table. Add water drop by drop using a medicine dropper, and keep on counting until water spills over (Figure 2).
- Place a bottle between you and a lighted candle. Blow against the bottle towards the candle. The flame on the candle goes out.
- Push a balloon into a bottle and stretch the open end of the balloon back over the mouth of the bottle. Now blow hard into the balloon. The balloon will only inflate to a certain size without filling the bottle no matter how hard you blow.
- Place a ping-pong ball in the vertical flow of air from the nozzle of a hairdryer or air blower. The ball will remain suspended in air, moving up and down slightly above the nozzle (Figure 3).

Figure 3 Suspending a ball in blowing air

- Swing a bucket of water quickly overhead. The water stays in the bucket.
- Hold a strip of paper, approximately 5 by 20 cm, at one end between the thumb and forefinger. Bring the paper toward your lips and blow across the top of it. The strip will rise.
- Drill three holes in an empty juice carton, near the top, near the middle, and near the bottom. Plug the holes from the outside of the carton with one long strip of masking tape. Keeping it in a sink or large container, fill the carton with water and then remove the tape. Water will shoot out furthest from the bottom hole, then the middle hole, and least far from the top hole.
- Fill a 20–30 ml plastic cup up to the brim with water. Gently drop small paper clips into it one at a time. How many can you add before the water spills over?
- Take an empty 2-litre plastic bottle and rinse it with cold water. Pour about 20 ml of near-boiling water into it, swirl the bottle and then empty the water into the sink. Quickly replace the cap on the bottle, leave it on the table, remove your hands, and stand back. Watch what happens (Figure 4).

Figure 4 The crushed 2-litre plastic bottle after the demonstration

Final thoughts

Often, pre-service and in-service teachers may need resources to set up counterintuitive science demonstrations. In this internet age, it would be convenient if suitable resources were available online for easy access. In a project at Florida Atlantic University (Kumar, 2014) videos of selected counterintuitive demonstrations were made available online to assist students in an undergraduate science education course with their teaching practice experience in local classrooms. Students who participated in the project reported that the access-on-demand online resource materials on counterintuitive demonstrations resulted in prolonged enquiry exploring science concepts, and were welcomed by participating classroom teachers.

Counterintuitive demonstrations can promote student interest in exploring science across all age phases. They are also suitable for helping English language learners to improve their comprehension of academic content knowledge and language skills (Giouroukakis and Rauch, 2000). Counterintuitive demonstrations '*have a unique power to engage emotions and provoke thoughts*' (McCrory, 2013: 88). It is important teachers consider adding counterintuitive demonstrations to their teaching approach. In the test-driven education system in the United States, with dwindling class time for science lessons, this may be one way of teaching science effectively and engagingly to promote the spirit of enquiry in students.

References and further reading

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David Devraj Kumar is Professor of Science Education and Director of STEM Education Laboratory in the College of Education at the Florida Atlantic University.
Email: david@fau.edu