Creating Science – Puff Bottles & Air Pressure

How does the magic of the Puff Bottle happen? As a magician I cannot tell you, but as a scientist, I can help you figure it out for yourself! ***#CreatingSciencePuffBottles***

Suggested outcomes

(NOTE: This is by no means an exhaustive list of possible outcomes, neither is it intended that ONLY these outcomes can or should be met. Science is a deeply interrelated activity; all outcomes at all levels, when appropriate, should be integrated.)

Science understanding

- Physical sciences 2: A push or a pull affects how an object moves or changes shape.
- Chemical science 5: Solids, liquids and gases have different observable properties and behave in different ways.
- Physical sciences 7: Change to an object's motion is caused by unbalanced forces acting on the object.
- Chemical sciences 8: The properties of the different states of matter can be explained in terms of the motion and arrangement of particles.

Science inquiry skills

- Planning and Conducting F: Participate in different types of guided investigations to explore and answer questions, such as manipulating materials, testing ideas, and accessing information sources.

Science as a human endeavour

- Science as a human endeavour 5: Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena.

Science vocabulary words

Tier 1 – (Common words). Air, bottle, balloon.

Tier 2 – (Words with dual meaning). None at this time.

Tier 3 (Specialised vocabulary)

- Pressure – pushing in all directions, all the time. Gasses, liquids and plasmas all have pressure.

Warning

- Balloons may frighten some people, and inspire others to use them in inappropriate ways. Please be careful, pre warn sensitive children, and have a plan of action in case of allergies or panic attacks.
- Only allow adults to drill holes in the bottles.

Preparation

Always try something yourself before fronting the class or expecting them to give it a go.

You have been warned…

Also, this lesson plan assumes you have at least one bottle to demonstrate in front of the class to get their science thinking happening.

You will need:

- A see through, clean, clear plastic bottle. Remove labelling on at least one half to improve visibility. Small drink bottles will do, such as sprite or pop-tops. Larger bottles, or bottles of drinking water, tend to collapse under atmospheric pressure.
- A balloon. Younger children might need to stretch out the balloon before it can be blown up.
- Adults only: A means of making a hole in the bottom of the bottle. A drill makes a good hole, but a sharp knife will also do.

Depending on your teaching style, you might like to have children bring bottles to class the week before so you can have the holes drilled prior to the lesson. Alternatively, having the children witness the safe and responsible use of power tools may be just the kind of lesson outcome you're looking for.

Suggestions for other year levels

As always, more material is presented here than can be used by the average class during the average lesson time. However, since the students' questions can and should guide student learning, more material is presented for your convenience. Remember, it is not uncommon for students to only remember those points which answered their personal questions.

Younger:

Many children at this age cannot inflate balloons. Consider using the Puff Cup instead (see #CreatingSciencePuffCup.)

Some children may misinterpret this event socially – that is, they may consider it a fun magic show, or a chance to be silly. Help scaffold 'adult' scientific thinking by saying things like 'we can have fun with science, but we're never silly,' and 'in science, we try to find 'real' reasons why things happen.'

Middle:

This activity is well suited to this group, but air pressure is still a very difficult and abstract idea. Find ways to extend the experience and help them experience air pressure.

Teen:

Extend the learning. Have students calculate and then demonstrate the concept of air pressure.

Learning Intent (student friendly)

'We are learning to' (WALT): Test our ideas, and appreciate that some ideas in science must have us talking about things we cannot see, hear, or even feel. Sometimes we don't even know who came up with that idea, but we still use it!

Success criteria

'What I'm looking for' (WILF): Successful use of the puff bottle, and even more successful explanation of the idea of air pressure.

Student learning goals

Help students make a self-monitored learning goal for this lesson, such as 'understand why the balloon stays blown up if your finger is on the hole, even if you take your mouth away.'

Evidence of learning

How will you know when the learning goal is achieved? What EVIDENCE do you have that your students have met or exceeded the learning expectations?

Engage

Invitation

The teacher claims they are going to try and 'trick' the students with a magic trick, and the students' job is to try and work out how the trick works.

The teacher tells the students the balloon inside the bottle is magical, and the teacher can prove it. When they click their fingers the balloon stays blown up even though children can clearly see it is open to the outside air. Then, with a click of their fingers, the balloon obediently deflates …

(In reality after the teacher inflates the balloon they plug a small hole at the bottom of the bottle with their finger. Shhh, don't tell them yet!)

Explore

- ⇨ Encourage and validate student explanations of this phenomenon. You may like to ask students to write or draw their explanation personally to avoid embarrassment to students unfamiliar with this material. Remember, 'I don't know' is a valid explanation in science – it is the beginning of learning new things!

Exploration

Point out that scientists try to think of **Explanations** of how and why the world works – then they go about testing their ideas. These explanations are often called **Theories** (or more accurately at this stage of the research 'hypothesis') and the tests they use to explore their theories are called **Experiments**.

Have the students propose explanations (AKA '**theories'** – use the word) regarding why the balloon behaves in this obedient way. TEST THESE IDEAS – could it be simply a matter of timing that the teacher is used to? Is it the sound waves of the click itself?

Remember to praise all attempts at experimentation – ***experiments always work***, even if we don't get the results we expected. This is because the purpose of an experiment is to *learn something new*, **not** to prove that we are right. Therefore, even experiments that don't do what we expected have something to teach us, maybe even more than if they did work out. The goal of science education is to encourage young scientists to be experimenters, not give the impression that only students who get it right make good scientists.

Eventually, students should notice the fingers of the hand holding the bottle moving at certain important times (if not, draw their attention to it with 'maybe the important thing to notice isn't what this clicking hand is doing?') Allow them to explore the process until they are fully convinced covering the hole, and not a click, makes this trick work.

Explain

Concept introduction

Once students have worked out how to do the trick, point out that this still doesn't **explain why** the trick works – and these sorts of questions are what it takes to be a scientist.

<u>Here's my explanation</u>: This trick works because air has a property called air pressure - air is always pushing in all directions all the time – very hard! One way to understand this is because air is made up of teeny, tiny molecules that are moving very fast. When they collide with something they give it a little push. Because they are so small their individual pushes are simply impossible to feel, but get a hundred billion of them together and their combined little pushes can inflate balloons, lift up airplanes, and even rip the rooves from buildings during a storm.

Sometimes a certain place may have less air pressure than usual – maybe some of the air molecules were taken out, or they are moving slower (because they cooled down), or they suddenly have more space to move around in (and thus bump into things less often). If one place has less air pressure than the surrounding air, you can be sure that the surrounding air (which is pushing in every direction as well) will be trying to push into the area of low air pressure. If there is something in between the two places (like the air tight skin of a balloon), it will be pushed by the high pressure air towards the low pressure region.

I like to say that all air, everywhere, is always pushing in all directions all the time. This idea is called 'air pressure'. This is a great idea for challenging young learners in science – air pressure is invisible, yet so powerful it lifts cars off the road every day (what else is in tyres?) Encourage students who have trouble believing the idea that they can think about it and keep asking questions. You don't have to feel pressured into accepting any idea in science until the evidence and logic convinces you. Who knows, they may yet come up with a better explanation. It matters that students are talking about science ideas they don't fully understand, rather than numbly accepting alternate or incorrect concepts.

Concept Application

How does this relate to our bottle? When you blow into the balloon, you increase its pressure, so it inflates. As it inflates it pushes some of the air out of the bottle. Then you plug the hole – forcing the air in the bottle to maintain its air pressure. The air in the room, however, has the same air pressure it always had, and so continues to push into the bottle the same way it always did. However, instead of finding an equal pressure inside the bottle, your removal of some of the air makes the air pressure in the bottle much lower. So the air in the room pushes the balloon into the region of low pressure, squashing the low pressure air until their pressures again balance out again. It takes a bit of imagining and practice to get this idea, but it can be got.

At the very least leave students with the understanding that the air in the room is pushing into the bottle. It may leave more questions than it answers, but that's OK! As long as students understand there are things they don't understand yet, rather than understand something completely incorrect. The trick works because air is always pushing – it doesn't need anything other than a high enough temperature to help it. The air in the room is pushing the balloon in because there is less air inside the bottle to stop it.

Try inflating the balloon with the hole blocked right from the start – it's just about impossible. Partly because the hole is small and your finger is pretty strong, but also because even when empty, a bottle is full of air – and air is always pushing.

Yeah, but who came up with that idea?

We're not really sure. Great minds thought alike, and we don't really know if it was any one person who had the key insight about air pressure. Around 300 years ago people including Evangelista Torricelli and Daniel Bernoulli used the idea in their work with science. Perhaps you can help us decide who first came up with the idea called air pressure?

Elaborate

⇨ Ask students if they can design new ways to test this explanation, is it really sufficient? Can they think of further or better explanations, and the experiments needed to test them?

Why does air press?

Because it's made out of billions of billions of silent, invisible particles that are always moving.

How much air do you suppose is between you and outer space?

In a cube of about 1 meter on each side, there's about 1 KILOGRAM of air. Fill a 1 litre bottle with water. That's how much air there is just between your head and the roof.

Now there's a LOT more air between you and space.

So the air down here is pushing all the time, HARD. How hard?

Well, we can explore more ideas about air pressure in the next lesson.

Torricelli and the Pumping Problem

https://en.wikipedia.org/wiki/Evangelista_Torricelli

In the 1700s Torricelli used the concept of air pressure to explain why pumps cannot pull water up over 10 meters – because pumps work by making a gap somewhere, and the outside air pushed the water into the gap.

After about 10 meters, the water weighs down as much as the air is able to push up. Thus, pumps cannot pull water up over 10 meters.

What do you think?

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Evaluate

Success criteria

- ⇨ Review the Learning Intentions of this lesson with students. Was it met?

At the end of each class, review the learning objective and see how we did. Ask:

- Did you achieve your learning goal?
- What did you learn?
- What worked to help you achieve it?
- What might you do better next time?
- (If needed) where can you go for extra help or information?

Assessment

Prior learning:

Find out what students already know about;

- What is science? How does science get its ideas? What are experiments? What does it mean to test our scientific ideas?
- What is air? Have you heard of air pressure? How does air push things? Can air push things even if there is no wind?

Formative:

As students are learning, help them self-monitor their own learning and achievements.

Watch for the following misconceptions

- Air is nothing. [air is definitely something, it has weight, and it has pressure. Air is *there*.]
- Air can suck. [Air NEVER sucks, it only EVER pushes. The reason the balloon stays inflated is because the air in the room is pushing into the bottle, and now that there is less air at the bottom of the bottle it cannot push hard enough to make the balloon return to normal.]

Summative:

Help students consider ways they can communicate their new understanding to others, just as scientists need to do.

- Make up your own puff bottle, try it out on family and friends, then write a report about what they experienced and learnt.
- Try a poster explaining the science of the puff bottle.
- Make a presentation (using, say, PowerPoint) of your experiences creating knowledge through science with the puff bottle. What were your initial feelings? How did you discover how the puff bottle really worked? Do you think scientists use the same kind of process you just did?

So what?

Not only does air pressure keep car tires inflated, it keeps cars going (using fire in the pistons). It makes the weather, and it explains why your ears pop when you travel in an aeroplane. Air pressure is fun!

Not all ideas in science can be attributed to one person or group of people. They are old ideas, thought of independently by completely different people working on the same problem.

Creating science

Science understanding

In learning about air pressure via the puff bottle (and puff cup) students will learn that;

- Physical sciences 2: A push or a pull affects how an object moves or changes shape.
- Chemical science 5: Solids, liquids and gases have different observable properties and behave in different ways.
- Physical sciences 7: Change to an object's motion is caused by unbalanced forces acting on the object.
- Chemical sciences 8: The properties of the different states of matter can be explained in terms of the motion and arrangement of particles.

Science inquiry skills

As students strive to work out how to do the trick, using stretchy balloons and invisible air, they have the chance to;

- Planning and Conducting F: Participate in different types of guided investigations to explore and answer questions, such as manipulating materials, testing ideas, and accessing information sources.

Science as a human endeavour

As students discover that we don't even know who came up with the idea of air pressure, yet they are able to use this idea to develop explanations and make predictions, they see that;

- Science as a human endeavour 5: Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena.

Tips from the masters

Fingers OFF to blow the balloon up!!!

You will have to blow REALLY HARD to get the balloon to blow up – but once it's blown up you just need to keep your finger on the hole and it'll stay blow up forever (as long as no extra air can sneak back in!)