Creating Science – Viscosity

A special activity for honing the measuring and timing skills that are vital in the creation of reliable scientific knowledge. Also a very messy activity sure to be loads of fun! ***#CreatingScienceViscosity***

Suggested Outcomes

(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 leaves, when appropriate, should be integrated.)

Science understanding

- Chemical sciences 4: Natural and processed materials have a range of physical properties; these properties can influence their use.
- Chemical sciences F: Objects are made of materials that have observable properties.

Science inquiry skills

- Planning and conducting 5-6: Decide which variable should be changed and measured in fair tests and accurately observe, measure and record data, using digital technologies as appropriate. Use equipment and materials safely, identifying potential risks.
- Planning and conducting 3-4: Safely use appropriate materials, tools or equipment to make and record observations, using formal measurements and digital technologies as appropriate.

Science as a human endeavour

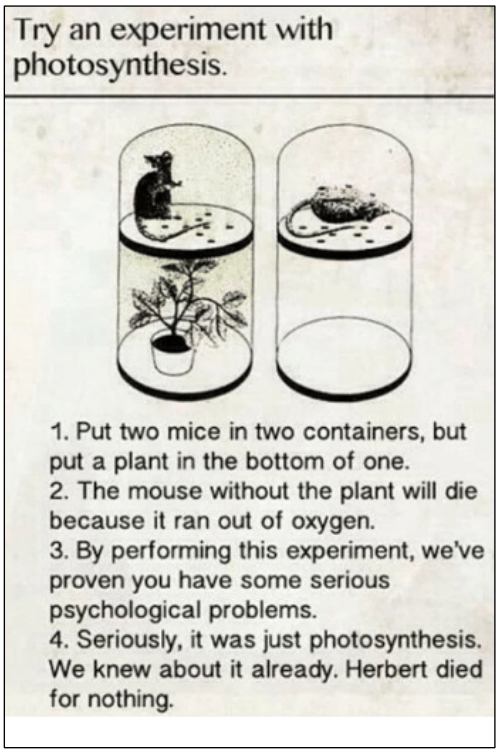
- Use and influence of science 4 & 5: Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE083).

Science vocabulary words

Tier 1 (Everyday words) – drop, time, measure, divide, average

Tier 2 (Dual meaning)

Experiment – Too often, we use this word in everyday speech to mean any activity that involves sciency things. Yet just because we have safety glasses and lab coats does not make it an 'experiment'. Many argue that *if we already know the results of the experiment, it's not an experiment at all!* Experiments are used to **create scientific knowledge**, not to show off what we already know – see satirical image:



True experiments may have one or many of the following:

- A prediction. You need a theory to generate a prediction, so many experiments offer a prediction for you to specifically test.
- Unknown answers. If you're not sure what will happen, it might be an experiment.

By this definition, going to a forest to estimate the spread of an invasive weed using a quadrat might be classed as an experiment – we don't know how many weeds there are before we begin, though we might expect to less than last time if the control measures are successful. But putting food dye into flower's water is a demonstration and not an experiment; we already know it will change the flower's colours, but it's still great fun to do, and a very valuable demonstration of science concepts of which we are well aware.

Tier 3 (Specialised vocabulary)

- Viscosity – the 'thickness' of a liquid. Cold honey is highly viscous, warm oil has a low viscosity.
- Repeated Measures – in order to create the best scientific knowledge possible, scientist will always test things as many times as they can, never just 'three times'. They will often try to keep as many variables the same between tests in an attempt to isolate the influence of just one variable, though this is not always possible.
- Fair tests – Tests are only fair if we can be sure of what we're testing. For example, if we tested tall boys and short girls for racing speed, what are we really testing, height or gender? We cannot be sure, and this test would not be fair.

Warning

- Prepare for mess. Have drop mats, suitable containers or sink benches to do this activity on, or work outside in the dirt.

Preparation

- Several clear plastic cups, or another kind of see-through container of standard lengths. The taller the better, but then stability may become an issue. Cups also have wide tops that make it easier to retrieve things dropped inside.
- Liquids of varying viscosity, depending on price and availability. Some examples might include water, vegetable oil, milk, chocolate syrup, honey, and tomato sauce. Other liquids you might try include hand sanitiser or glue – just make sure your marble CAN flow down through them before giving them to the class
- Things to drop in the cups of a standard size and weight. Glass marbles are often fine. (Or get metal marbles if the liquids are highly viscous).
- Stopwatches for everyone.
- A whiteboard or similar to write up results (computers and laptops can be made to generate graphs very quickly.)

Disposal

Salt water goes down the sink to the sea – after all, the sea is salty! If you pour it out on the garden it will kill the plants there, and potentially make the ground unsuitable for plants in the future.

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:

This activity can be very tricky for this age group, and will require grown up help. Yet even Foundation students can quickly gain the concept that the marble is slower in some liquids than others, can have fun using stop watches, and can appreciate the importance of using maths to compare 'higher' to 'lower' when it comes to determining which liquid is more 'viscous'.

Middle:

Messy, but fun. Unless they are able to appreciate the importance of EXACT MEASURES to this activity they are unlikely to remain on task.

Have them participate in their own learning by suggesting and bringing in their own liquids to measure (added caution here).

Teen:

First and foremost, empower older students with an appreciation of viscosity – from makeup to motorcycles, viscosity is vital to having things run smoothly in society. What other times might viscosity be vitally important to everyday life? If they drive any car at all, they're going to need to know the difference between a 10W-40 oil and a 40W-70 oil – beside from price.

Engage

Mess around with a non-Newtonian fluid – cornstarch and water (often called 'Oobleck').

Explain: **Viscosity** is the 'thickness' of a fluid. It's important to be able to measure the viscosity of fluids - for example, in sewage, the slant of the pipe depends on how viscous the sewage is expected to be. Too flat and there will be a build-up of the yucky stuff! Too sloped, and there will need to be very deep trenches dug to hold the pipes, which is a lot of work and too many pumping stations will have to be built.

- ⇨ Get a clear tube and pour various liquids down it. Note how slope determines whether some fluids will flow at all.

Ask: How can we determine as precisely as possible which liquid is more viscous than the others? (Answering this question is the main goal of this activity).

Explore

⇨ Help students develop a test for viscosity (and they may even come up with a better one) similar to the following (see related student activity sheet).

Fair tests

HELP STUDENTS UNDERSTAND the importance of a fair test.

- Good science knows what it is testing, and doesn't allow for other random factors to influence the results (or, at the very least, admits it when they might have).
    - How about putting one plant in the cupboard and one in the sunlight, and seeing which grows the best? But are you really testing lighting conditions, or how much space there is around the plant to help it grow? Again, controlling such factors can be a real quest in science! Perhaps there were some special nutrients in the soil between the plants, since we can't actually use the same soil to grow two different plants! We must always be on the watch out for testing things we didn't mean to test.
    - So in the current instance, if different sized marbles are used each time can you really say what you're testing: viscosity or marble size? So as much as is possible, the marbles need to be the same size and weight.
- These factors in science are called variables.
    - The Independent variable is the one you change deliberately, to see its effect.
    - The Dependent variable depends on the independent variable for its effect.
    - Controlled variables are the ones you must deliberately keep the same so that they keep your test fair.
- You can remember these little variables with the mnemonic "Cows Moo Softly" – what do we Change, What do we Measure, and what do we keep the Same? (developed by the good people at Ironside state school and STAQ).
- Of course, sometimes testing only one thing at a time simply isn't possible. Some very high end science must deal with multiple dependent variables at once, and develops some very complex mechanisms for dealing with multiple variables which, in my opinion, makes that science very exciting! (Such as ANCOVA tests, etc.). You don't need only ONE variable to consider it science (Astronomy would agree, they can't change variables at all! They must simply see if their theories are supported by observation).

Fair testing can quickly become a very complex one, but a necessary one if we are to create excellent scientific knowledge. Keep up the quest!

Repeated measures

Some variables simply cannot be controlled, and are often called confounding variables. For instance, what if you wanted to test new medicine effects on preventing disease? So you found two people willing to be tested and give one of them the drug and the other one a sugar pill, being very sure to make sure neither you nor they know which is which. This is called the 'double blind' test.

HOWEVER, by sheer luck, you managed to give the drug to someone whose body was very good at fighting off disease, and the sugar pill to someone who gets sick a lot. Are you results really fair? How can you make your results fair when you just can't control for every variable possible?

The logic is that the only way is to RANDOMLY select AS LARGE A NUMBER of participants as possible, so that each has the same chance of being given the drug or the sugar pill, and hopefully with a large enough sample such random factors such as health and disease resistance will be negligible or weeded out altogether. How? Read on.

- ⇨ HELP STUDENTS UNDERSTAND the importance of repeated measures.

In the social sciences the usual number of tests is 30 multiplied by the number of independent variables. So, for instance, testing the effect of gender on spatial intelligence you need sixty trials (one for boys, one for girls).

Different sciences have different requirements. Some tests can really only be performed once.

Some tests are so sensitive it might take thousands, if not millions, of measurements before the result will be detailed enough. Take, for instance, the hunt for the Higgs-Boson particle at the Large Hadron Collider which required over 600 million collisions every second for two years!

- ⇨ Tally up student results to find the average speed of the marble moving through the liquid.

Explain

Explain: it is believed that viscosity is caused by friction (and other things) between the particles in the liquid. There is always more friction near the edges of a container than the middle, which is why rivers and even water in a hose will travel faster near the middle and slower at the edges. Lowering friction by, say, heating the liquid up will result in less friction and thus less viscosity.

High school

Explain: Viscosity is often measured in **Pascal-seconds** (Pa·s).

$$\text{Viscosity} = \frac{\text{Weight in kilograms, divided by}}{\text{Speed of the object in meters per second}}$$

And you can get the speed of the marble by: Height of the liquid (in meters) divided by the time it took to cross that distance (in seconds)

- ⇨ Using this information, calculate the viscosity of each liquid.

Elaborate

Invite students to think of other liquids they could test.

- ⇨ Test honey, and then heat it up. Does the viscosity change with heat?

Note that in order to make this test fair, the liquids should all be the same temperature.

So what about the Oobleck? It is known as a dilatant fluid, a kind of non-Newtonian fluid because it *gains* viscosity when put under stress!

Factors affecting viscosity

Viscosity affects a lot of things, but what affects viscosity? Research some answers, such as:

- The materials being used. For example, adding water or oil can lower the viscosity of certain materials, making them easier to spread around. Engine oil additives sometimes promise this, but is it always a good thing?
- Temperature is a big influence, but it does depend on the material. For example, is it easier to spread butter on to hot toast, or room temperature bread?
- Pressure can affect the viscosity of gasses, but will it affect you?

The pitch drop experiment.

A wonderful demonstration of super high viscosity, this 'liquid' illustrated below has been dripping from a glass funnel at the University of Queensland for over 80 years (beginning 1923). In all that time, it has only dripped eight times! You can see a live web cam of the very boring liquid, occasionally including students from the university.

Figure 1 From http://smp.uq.edu.au/content/pitch-drop-experiment taken 4th june 2014

Some kinds of glass are considered super viscous. You may know some very old fashioned glass that over time develops small ripples as it gently flows down the window, becoming thicker at the base than the top.

Evaluate

- ⇨ Review with students what they felt they learnt from this lesson. Did they have any questions at the start that they feel were answered?

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:

Ask students what the Oobleck feels like. Can they think of a name for the way it is sometimes runny, sometimes not?

Are all liquids runny? Are some runny, and some runnier?

Formative:

Focus on the outcomes – how can we create the BEST scientific knowledge?

What does it mean to have a fair test? How can we make our tests fairer?

- Why is it important to use exact measures? How important is it that scientists are very precise when they measure things like the influence of medicine, or the amount of damage in crash tests? **How can we improve the exactness of our measurements**?
- What is viscosity? Which is more viscous, peanut butter or motor oil?

Be sure to watch out for the following common alternative conceptions:

- Don't mix up viscosity with slipperiness. While they are often related, they are not the same. Viscosity affects flow rate. Butter is still very slippery whether it's a melted liquid or solid chunk of fat.
- Viscosity is not density – how squished up the particles are. Butter is often less dense than water (it will float) but it is a lot more viscous!

Summative:

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

- Present a report during a 'conference' of the students' conclusions regarding their viscosity investigation. Have them propose the best liquid for:
    - Slowing things down
    - Having things move quickly through them
- Tackle some 'real world' problems and, using the results of their research, answer the following:
    - Scientists are preparing to visit a strange, imaginary, planet. This planet has an atmosphere with a viscosity ten times that of planet Earth, and at 15 °C, the viscosity of air is 1.81×10−5 kg/(m). What material do you suggest they submerse their astronauts in for training in this strange environment?
    - Marco is having trouble getting his butter to spread on to his bread. What two things can he do to make it easier?
- Collect several media articles about scientific research:
    - Were they using fair tests?
    - Did they have repeated measures?
    - Were they using precise measurement?

So what?

From makeup to motorcycles, viscosity is vital to having things run smoothly in society, i.e., knowing about motor oil and some medicines.

Two tricks exist to lower viscosity and make things runnier: adding new materials with a lower viscosity, or heating the liquid up.

Exact measures and fair tests are vital to making science the best it can be – keep a look out for those kinds of science that are only trying to LOOK scientific, but in fact are simply advertisements dressing up as science.

Creating science

Science understanding

As we learnt that different liquids have different viscosities, we saw that;

- Chemical sciences 4: Natural and processed materials have a range of physical properties; these properties can influence their use.
- Chemical sciences F: Objects are made of materials that have observable properties.

Science inquiry skills

In developing precise measurements as a virtue in science, and making our tests fair, we;

- Planning and conducting 5-6: Decide which variable should be changed and measured in fair tests and accurately observe, measure and record data, using digital technologies as appropriate. Use equipment and materials safely, identifying potential risks
- Planning and conducting 3-4: Safely use appropriate materials, tools or equipment to make and record observations, using formal measurements and digital technologies as appropriate.

Science as a human endeavour

People use science to help them make decisions every day, from what motor oil to use, to how thick they need to spread their peanut butter, as in:

- Use and influence of science 4 & 5: Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE083).

Appendix – Tips from the masters

Be sure to use a stopwatch or smartphone!

Oobleck is soo much fun!!