ASELL SCHOOLS Advancing Science & Engineering through Laboratory Learning TEACHER NOTES

Viscosity: Teacher Notes

Overview/Introduction

We deal with flowing liquids all the time. Getting sauce out of a bottle. The spread-ability of honey, jam and butter. Whether dressing stays on salad or drips off. The time taken for water to flow through the tap to fill the kettle. The flow-ability of shampoo is one of the factors that determine how shampoo spreads through our hair.

Viscosity is the resistance to flow. Liquids with high viscosity do not flow easily; liquids with low viscosity flow easily.

This activity has its genesis in the materials science research conducted at Deakin University's Institute of Frontier Materials. http://www.deakin.edu.au/research/ifm/.

Specifically, in research aimed at improving the rate of production of carbon fibre composite materials. Currently carbon fibre objects cannot be made fast enough to keep pace with the production lines of major car companies. So, rapid production of carbon fibre composite material is necessary if this very strong and lightweight material is ever to replace metals in the mass manufacture of motor vehicles.

In the production of carbon fibre composite, the resin component must spread through the carbon fibre cloth, and the rate at which the resin spreads through the fibre cloth depends on the viscosity of the resin.

There are many other industrial examples. Paint needs to be thin enough to spread with a brush or roller or to be sprayed from a spray gun, but also viscous enough not to run off the surface to which it has been applied before it "dries". 'Oils' and lubricants have been devised to achieve a viscosity at the operating temperatures of the machine so they will penetrate the narrow spaces between moving parts to lubricate the surfaces. Liquids that are packaged must be able to flow through the packaging machinery, but have the appropriate qualities for use after packaging.

The viscosity of a liquid changes with temperature. In this activity, students investigate changes in the viscosity of honey at different temperatures. This has further relevance in the context of the carbon fibre problem because the curing of the resin also has an optimum temperature. If the temperature is too high the resin may harden before it has spread through the fibres.

The LLA also provides a context in which students can develop science inquiry skills and a conceptual understanding of how the properties of materials are determined by the forces between particles both within materials (cohesive forces) and between materials and the surfaces with which they are in contact (adhesive forces).

This LLA addresses learning outcomes related to the particle model of matter, science inquiry with specific focus on Identify questions, problems and claims that can be investigated scientifically and make predictions based on scientific knowledge. The application of science understanding in solving problems will also be considered.

Curriculum Outcomes: Australian Curriculum - Science F-10 [Footnote 4]

Years 5 and 6

Science as a human endeavour: Use and influence of science

- Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE083 & ACSHE100)

Year 7

Science as a human endeavour

- People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE121)

[4] http://www.australiancurriculum.edu.au/science/curriculum/f-10?layout=1#level5

Year 8

Science as a human endeavour

- People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE136)

Science Understanding: Chemical Sciences

- Properties of the different states of matter can be explained in terms of the motion and arrangement of particles (ACSSU151)

Curriculum Outcomes: Australian Curriculum - Design Technologies

Years 5 and 6

Design Technologies

- Explore the characteristics and properties of materials and components that are used to produce designed solutions (ACTDEK004)

Curriculum Outcomes: Victorian Curriculum F-10 [Footnote 5]

Levels 5 and 6

Science Understanding: Science as a human endeavour

- Scientific understandings, discoveries and inventions are used to inform personal and community decisions and to solve problems that directly affect people's lives(VCSSU073)

[5] http://victoriancurriculum.vcaa.vic.edu.au/Print

Levels 7 and 8

Science Understanding: Science as a human endeavour

- Scientific knowledge and understanding of the world changes as new evidence becomes available; science knowledge can develop through collaboration and connecting ideas across the disciplines and practice of science (VCSSU089)
- Science and technology contribute to finding solutions to a range of contemporary issues; these solutions may impact on other areas of society and involve ethical considerations (VCSSU090)

Science Understanding: Chemical Sciences

- The properties of the different states of matter can be explained in terms of the motion and arrangement of particles (VCSSU096)
    - modelling the arrangement of particles in solids, liquids and gases.

Science Understanding: Physical sciences

- Change to an object's motion is caused by unbalanced forces acting on the object; Earth's gravity pulls objects towards the centre of Earth (VCSSU103)
    - investigating the effects of applying different forces to familiar objects.

Curriculum Outcomes: Victorian Curriculum – Technologies F-10 [Footnote 6]

Design and Technologies: Technologies Contexts

- **Materials and technologies specialisation**. Analyse ways to produce designed solutions through selecting and combining characteristics and properties of materials, systems, components, tools and equipment (VCDSTC048)

[6] http://victoriancurriculum.vcaa.vic.edu.au/level8?layout=1&d=DE

Key Knowledge and Skills

In completing this activity, students explore and apply a range of concepts and terms. Some of these terms and concepts are described, defined and explained below.

Viscosity - The resistance to flow. More precisely, the resistance to change shape by when a force is applied.

Force - A force is a push or a pull. A force can cause movement in an object or cause compression, tension or torsion within the object.

Adhesive forces - The force of attraction of the particles (molecules) of one material for another. For a water drop on a window these would be the forces of attraction between water molecules and the glass molecules.

Cohesive forces - The force of attraction of the particles (molecules) of within a material. For a water drop on a window these would be the forces of attraction between water molecules and the glass molecules.

Flow - The movement of a fluid.

Flow rate - The amount of fluid that has moved in a given time.

Fluid - A fluid is a material than can flow. It can be either a liquid or gas. Fluids can flow to take the shape of their container. Technically, a fluid is a substance that continuously changes shape or flows when a force is applied.

Investigation - A scientific process of answering a question, exploring an idea or solving a problem that requires activities such as planning a course of action, collecting data, interpreting data, reaching a conclusion and communicating these activities

Variable - Something that can change.

Dependent variable - Variable that changes in response to changes in the independent variable and that is observed or measured.

Independent variable - Variable that is deliberately changed.

Controlled variables - Variables that are kept constant.

Fair test - When testing different materials all the variables except the one being tested need to be kept the same.

Key Science Inquiry Skills

In conducting these activities, students need to:

- identify a hypothesis
- identify variables relevant in the test
- determine the independent, dependent and control variables
- take steps to ensure accuracy in measurement
- plan and conduct an investigation
- record data systematically
- analyse data
- draw conclusions based on evidence

Background information

Viscosity is the resistance of a liquid to flow. A viscous or thick liquid such as honey flows slowly when it is poured from one container to another, but a thin or low viscosity liquid such as water flows relatively quickly. The difference in flow is caused by internal friction generated between the molecules that make up the liquid.

Let us consider two glass sheets with a film of water between them and what happens when we slide one plate sideways. Adhesive forces hold water molecules to the surface of the glass and cohesive forces hold the water together.

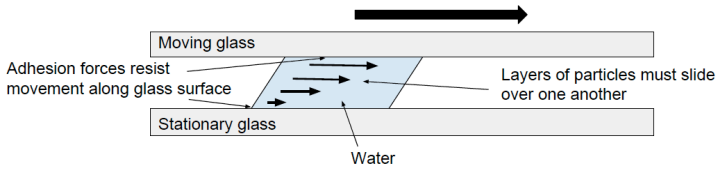

Diagram by Ian Bentley.

When a liquid flows, layers of the fluid slide over one another. The strength of attraction between the molecules in each layer will determine the strength of the resistance to flow. Think about how much harder it would be to slide the glass plate if the liquid was honey rather than water.

The viscosity of a liquid decreases as the temperature increases. This is obvious with oils and honey but water at 100°C is about on third the

viscosity of water at 20°C. A conceptual challenge for students in this activity is to represent why the viscosity is lower at higher temperatures.

Pedagogy

Inquiry Skills

This is an inquiry activity that can be adjusted by the teacher to be as guided or as open-ended as desired. In this activity, special emphasis is given to identifying questions and making predictions based on scientific knowledge. The students are provided with a procedure and then asked to make predictions and identify question can be answered using the procedure.

Teachers may use the inquiry scaffolding tool[7] to assist decision making about the degree of support to provide students for each phase of the inquiry process.

[7] Inquiry scaffolding tool. National Research Council (2000); Bruck, L.B., Bretz, S.L., & Towns, M. H.,2008. Adapted for the Victorian Curriculum by Lim, K. F. (2016), unpublished.)

Curriculum outcome (slightly paraphrased)	Structured Inquiry	Guided Inquiry	Open Inquiry	Prescription	Confirmation	Curriculum outcome (slightly paraphrased)
Identify questions (VCSIS107)	Student sharpens or clarifies a question provided by teacher, or other source	Student selects among questions, poses new questions	Student poses a question	No question	Student engages in a question provided by teacher, or other source	Identify questions (VCSIS107)
Plan and conduct investigation (VCSIS108)	Student sharpens or clarifies a plan provided by teacher	Student selects among plans	Student plans and conducts investigation	Student is given plan of investigation	Student uses a plan provided by teacher	Plan and conduct investigation (VCSIS108)
In fair tests, select equipment to collect data (VCSIS109)	Student is told how to select equipment for a fair test	Student selects among equipment	Student selects equipment	Student is given data	Student is told how to use equipment to collect data	In fair tests, select equipment to collect data (VCSIS109)
Construct and use representations, to record and summarise data (VCSIS110)	Student is guided to represent and summarise data	Student selects among representations and summaries	Student determines and uses representations and summaries	Student is given representations and summaries of data	Student told how to represent and summarise data	Construct and use representations, to record and summarise data (VCSIS110)
Identify relationships, evaluate claims and draw conclusions (VCSIS111)	Student is given relationships and evaluations, and guided towards conclusions	Student is directed to evaluate claims and selects among possible conclusions	Student evaluates claims and draws conclusions	Student is given conclusions	Student is given relationships and evaluations, and told how to draw conclusions	Identify relationships, evaluate claims and draw conclusions (VCSIS111)
Reflect on the method used and evaluate data (VCSIS112)	Student told how to reflect and evaluate	Student is guided toward reflection and evaluation	Student reflects on the method and evaluates data	Student is given evaluation	Student is given reflection and told how to evaluate	Reflect on the method used and evaluate data (VCSIS112)
Communicate ideas, findings and solutions to problems , using scientific language (VCSIS113)	Student is provided broad guidelines to use to sharpen communication	Student is coached in development of communication	Student communicates ideas, findings and solutions	No communication	Student is given steps and procedures for communication	Communicate ideas, findings and solutions to problems , using scientific language (VCSIS113)

Conceptual Development

Through this activity, it is possible to extend students' understanding of the particle model of matter. The properties of a material are dependent on the nature and strength of in the intermolecular forces. There are two questions in the Discussion/Conclusion that encourage students to think about the flow of a liquid at the (molecular) particle level. This is a conceptual challenge and students may need to be asked leading questions if they get stuck. Students may need to be shown a simulation of particle being poured e.g. sand or rice grains. They then need to use their imagination and what they know about the behaviour of particles in a material as it is heated to explain which liquids become less viscous when they are heated.

Representation construction approach

Using a representation construction approach (Tytler, Prain, Hubber and Waldrip 2013) can help. The teacher can encourage the students to represent a honeycomb structure. The representation could show the forces involved and shape changes as loads are added to the various structures.

The representations will most likely to be drawings (annotated diagrams), but they could also be models or role plays. Such representations provide insight into students' conceptions. Whatever form the representations take they afford an opportunity to engage with the students in dialogue about their conceptions with the purpose of developing and refining their representations and hence their conceptualisation of particles in a viscous liquid when it is poured and when it is heated.

Assessment

The teachers can compare the student's performance with the curriculum descriptors and make judgements about whether the outcomes have been achieved. Peer and self-assessment of effectiveness of created composite structures.

References

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Suggestions

Suggestions for improvements of these activities should be sent to the Project Officer, ASELL for Schools (Victoria), Ian Bentley i.bentley@deakin.edu.au

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