SCHOOLS Advancing Science & Engineering through Laboratory Learning TEACHER NOTES

Composite materials: Teacher Notes

Overview/Introduction

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/.

This Laboratory Learning Activity (LLA) addresses some of the principles that are currently being investigated through research and design at the Institute.

The composite materials activity enables students to experience and investigate the way combining the properties of two materials (styrofoam and duct tape) can result in a composite material of different properties: in this case in significantly increased strength. In the process the students learn about tension and compression forces.

Initial questions are designed to tune-in students. The focus here is on what materials are used to make racing cars and surfboards. Carbon fibre and fiberglass are good examples of resin composite materials. These materials are a bit tricky to use in a class so we substituted for readily available and easy to use products. We have focused on sandwich materials.

This LLA addresses a range of outcomes described in the Australian and Victorian Curricula. It particularly addresses outcomes related to the effect of unbalanced forces on an object's change in motion, science inquiry with specific focus on recording and processing data and the application of science understanding in solving problems.

Curriculum Outcomes: Australian Curriculum - Science F-10

Level 7 (Footnote [1])

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)

Science Understanding: Physical sciences

- Change to an object's motion is caused by unbalanced forces, including Earth's gravitational attraction, acting on the object (ACSSU117)

Curriculum Outcomes: Victorian Curriculum F-10

Levels 7 and 8 (Footnote [2])

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: 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.

[1] http://www.australiancurriculum.edu.au/science/curriculum/f-10?layout=1#level7

[2] http://victoriancurriculum.vcaa.vic.edu.au/

Curriculum Outcomes: Victorian Curriculum – Technologies F-10

Design and Technologies: Technologies Contexts

- **Engineering principles and systems**. Analyse how motion, force and energy are used to manipulate and control electromechanical systems when designing simple, engineered solutions (ACTDEK031)
- **Materials and technologies specialisation**. Analyse ways to produce designed solutions through selecting and combining characteristics and properties of materials, systems, components, tools and equipment (ACTDEK034)

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.

Bending – The shape or force (something straight) into a curve or angle.

Composite material – A material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components.

Composite sandwich material – a composite material with the individual materials in separate and distinct layers within the finished structure.

Flexibility – The extent to which an object can be bent without breaking.

Rigidity – Inability to bend or be forced out of shape

Stiffness – The resistance to changing shape when forces are applied. A stiff material doesn't bend or twist easily.

Force – a push or a pull.

Compression force – a push that squeezes an object to try to make it smaller or shorter.

Tension force – a pull stretches an object to try to make it bigger or longer.

Strength – The ability of a material to resist breaking when a force is applied.

Key Science Inquiry Skills

In conducting these activities, students need to:

- take steps to ensure accuracy in measurement
- construct and use a range of representations to record data systematically and using graphs
- analyse patterns and relationships in data and graphs
- draw conclusions based on evidence
- plan and conduct an experiment

Background information

Composite Materials

A composite material is made from two or more materials, each with different physical or chemical properties. But when combined, the whole composite has properties that are different from the individual materials.

Some composite materials are mixtures, like cements, concrete, imitation granite and cultured marble sinks and countertops, and metal alloys.

Some composite materials have one material embedded inside the other material, for example, fiberglass, concrete with steel reinforcement, and mud bricks with straw reinforcement.

Some composite materials have the individual materials in separate and distinct layers.

Scientists and engineers are developing new composite materials because they can be stronger, lighter, or less expensive when compared to traditional materials. Engineers have many choices during the manufacturing process to determine what the properties of the resulting composite will be. Modern aviation has been a primary driver

for composite materials, as it has great demand for materials that are both light and strong.

Composite Sandwich Materials

Composite sandwich materials have the individual materials in separate and distinct layers within the finished structure. Composite sandwich materials are used in buildings, bridges, boat hulls, race car bodies, spacecraft and aircraft.

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. The student notes begin with specific directions but later questions allow students to conduct more independent investigations. The teacher may, however, decide to provide close guidance and direction throughout the activity.

Teachers may use the inquiry scaffolding tool[3] to assist decision making about the degree of support to provide students for each phase of the inquiry process.

The activity presented in the student notes is designed to move the student from a directed inquiry through to more independent inquiry. The reason for starting with more direction is so that the students have some knowledge and experience to apply to more open-ended investigations later on such as creating a stronger composite material using the least amount of tape.

[3] 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)

In Part 1 the students observe the effectiveness of sandwich structures using a polystyrene plank and tape.

In Part 2 they then re-do the demonstration with their group comparing three products:

- polystyrene on its own and
- one composite material
- a second one composite material with different structure.

They consider different types of sandwich structures (open vs regular). They construct and use a range of representations to record data systematically and using graphs and analyse patterns and relationships in data and graphs.

Conceptual Development

In addition to the development of inquiry skills an intended learning outcome of these activities is to have students refine their understanding of the static forces of compression and tension.

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 composite structure. The representation could show the forces involved and shape changes as loads are added to the various structures created or showing the arrangement of various materials used in making the composite 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 composite materials and their components.

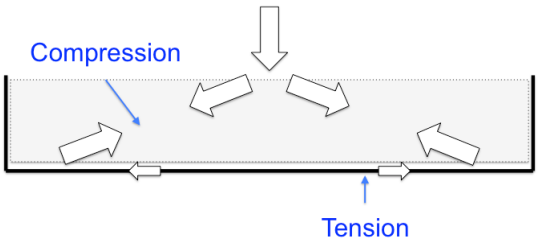
Discussion points

Forces in the composite structure

In analysing the forces in the composite structure, effectively only 2 elements span the sandwich structure.

The tape on the bottom is under tension as weight is applied.

Like the roof and bridges, the (mostly) top polystyrene is under compression. The tape on the top is effectively doing nothing.



This question is worth engaging in class discussion – unpack the ideas around sandwich structures and how they can increase strength and rigidity (and what are these qualities useful for?).

This is a good representation construction activity.

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

Bruck, L.B., Bretz, S.L., & Towns, M. H. (2008) Characterizing the level of inquiry in the undergraduate laboratory. Journal of College Science, 38(1),52-58.

National Research Council (2000). Inquiry and the national science education standards: A guide for teaching and learning. Washington DC: National Academic Press.

Tytler, R., Prain, V., Hubber, P., & Waldrip, B. (Eds.). (2013). Constructing representations to learn in science. Springer Science & Business Media.

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

Nova. (2016). The science and technology of composite materials. www.nova.org.au/technology-future/composite-materials

https://www.slideshare.net/GranchBerheTseghai/2-textile-reinforced-composites-52380588

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

Copyright and Creative Commons