Anglophone School District - North

Grade 3 Science - Unit Lesson Guide

Materials and Structures

Table of Contents

The Aim of Science Education - Scientific Literacy

The aim of science education in the Atlantic Provinces is to develop scientific literacy.

Scientific Literacy is an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving, and decision-making abilities; to become lifelong learners; and to maintain a sense of wonder about the world around them. To develop scientific literacy, students require diverse learning experiences that provide opportunities to explore, analyze, evaluate, synthesize, appreciate, and understand the interrelationships among science, technology, society, and the environment.

The Three Processes of Scientific Literacy

An individual can be considered Scientifically Literate when he/she is familiar with, and able to engage in, three processes: Inquiry, problem solving, and decision making.

Inquiry

Scientific inquiry involves posing questions and developing explanation for phenomena. While there is a general agreement that there is no such sing as the scientific method, students require certain skills to participate in the activities of science. Skills such as questioning, observing, inferring, predicting, measuring, hypothesizing, classifying, designing experiments, collecting data, analysing data, and interpreting data are fundamental to engaging science. These activities provide students with opportunities to understand and practise the process of theory development in science and the nature of science.

Problem Solving

The process of problem solving involves seeking solutions to human problems. It consists of proposing, creating, and testing prototypes, products, and techniques to determine the best solution to a given problem.

Decision Making

The process of decision making involves determining what we, as citizens, should do in a particular context or in response to a given situation. Decision-making situations are important to their own right, and they also provide a relevant context for engaging in scientific inquiry and/or problem solving.

Science Assessment Overview

Science is a hybrid term that houses different disciplines such as: Physics, Chemistry, Biology, Environmental Studies, Engineering, Math, etc. Given this broad spectrum, it is not realistic that we can paint science assessment with a single brush in terms of probes that work for every science activity. However, regardless of school subject, let alone science, the frequency of assessment should be unbalanced with formative assessment occupying 80% of practise and summative with the remaining 20%.

80% Formative - 20% Summative

Formative Assessment
Formative assessment is a range of formal and informal assessment procedures employed by teachers during their learning process in order to modify teaching and learning activities to improve student attainment. It typically involves qualitative feedback (rather than scores) for both students and teacher that focuses on the detail of content and performance. Feedback is the central function of formative assessment. It typically involves a focus on the detailed content of what is being learnt.

Science Formative Assessment falls into 2 distinct categories, and they are divided about how feedback is given. Please be aware that an activity could be informal or formal, it is the purpose of the task that determines purpose.

Informal Formative
Informal Formative Science Assessment acts as a monitoring probe and is distinct because it is not graded.

Formal Formative
Formal Formative Science Assessment provides specific feedback to students, the teachers corresponds via anecdotal feedback, rubrics, and written responses to offer progress to student attainment.

Summative Assessment
Summative assessment seeks to monitor educational outcomes, often for the purposes of external accountability. Usually occurring at the end of a learning unit and determines if the content being taught was retained.

Materials and Structures

Focus and Context

The focus of this unity is problem solving. Students should be provided with a number of challenges or design tasks over the course of the unit. Upon receiving these the student will follow steps in the problem solving process to design solutions.
Proposing: Students should be given opportunities to research a variety of designs already in use, and investigate the properties and ways of joining materials to see why they will be suitable for the particular task or challenge. They will then in a position to propose solutions to the task or challenge. Creating:Students gather materials and tools they have chosen and design a solution to the task or challenge. This will involve revisions of the original plan as problems are encountered.
Testing: Student will test and evaluate their design, compare it to the design of others, and refine their designs as appropriate.
Students should be presented with several structural challenges or tasks that require individual or small groups to complete the design technology cycle. These challenges should involve using a variety of materials, the acquisition of a variety of techniques for joining materials, and improving the strength and stability of structures.

*The entire Materials and Structures unit is covered in the EECD Inquiry Resource Package developed in 2009. The section presented is the entire package of lessons verbatim. For further support of these lesson please consult the Materials and Structures Inquiry resource package.

**The additional lesson presented are discovery based an can be used as reinforcers to the STSE/Knowledge (100) outcomes. The purpose of these lesson is to add as much discovery and investigation using science skills (200) outcomes.

Unit Instructional Overview

Proposing Solutions to Building Challenges*	Creating Solutions to Structural Challenges*	Evaluating the Structural Solutions*
Access Prior Knowledge		
1st Cycle - Activity - Building Structures		
2nd Cycle - Activity - Properties and Uses of Materials		
3rd Cycle - Activity - Joining Materials		
4th Cycle - Activity - Materials and Shapes		
5th Cycle - Activity - My Second Structure		

* - EECD Grade 3 Inquiry package - available at
https://portal.nbed.nb.ca/tr/lr/k-8Science/Pages/default.aspx

Materials and Structures - Curriculum Outcomes

Proposing Solutions to Building Challenges	Creating Solutions to Structural Challenges	Evaluating the Structural Solutions
202-2 Identify problems to be solved while creating structures	101-10, 201-3 Use appropriate tools to safely cut, shape, make holes, and assemble materials	101-9, 202-8 Test the strength and stability of personally built structures, and identify ways of modifying a structure to increase its strength, stability, form, and function
100-34 Describe the properties of some common materials, and evaluate their suitability for use in building structures	201-8 Follow safety procedures and rules while constructing structures and explain why they are needed	202-5 Identify materials or parts of a structure that failed and suggest why
101-11 Investigate ways to join materials and identify the most appropriate methods for the materials to be joined	201-6 Estimate measurements in order to select required materials for their structure	102-17 Evaluate simple structures to determine if they are effective and safe, if they make efficient use of materials, and if they are appropriate to the user and the environment
102-16 Identify shapes that are part of natural and human-built structures, and describe ways these shape help provide strength, stability, or balance	201-2 Manipulate materials purposefully to create the structure	203-3, 203-2 Illustrate their construction process, using drawings with written explanations, and/or oral descriptions and demonstrations; and describe the structures and components of the structures they have built
200-5 Identify materials that could be used to solve the problem posed, and suggest a plan for how they will be used	203-5 Respond to the ideas of partners while constructing the structure, acknowledge these ideas and contributions, and make changes in the structure as deemed necessary	

New Brunswick Nouveau-Brunswick
Be...in this place • Être...ici on le peut

Science Resource Package: Grade 3

Materials and Structures

New Brunswick Department of Education

December 2009

ⓘ Background Information

Prior Knowledge:

Students have likely used blocks and Lego and can build structures from familiar materials but do not have defined ideas about what makes structures strong or weak.

Students may know there are man-made things of different shapes, heights, and made from different materials.

Common Misconceptions:

When presented with a pile of materials, students may they think they can build anything.

Structures have to be rectangular.

Did You Know?

A structure is anything that is built, has more than one part and was built for a particular purpose. Examples include umbrellas, bookshelves, nests, ladders, chairs, bridges, bike helmets, shoes, and towers.

The "Build It Up" Teacher's Guide has useful background information.

page 32: information on arches and triangles

page 37: information on triangles and braces

page 44: information on domes

page 55: information on joints

Examples of joining materials are hinges, bolts, tape, staples, solder, and paperclips.

The following website provides excellent information and pictures about different types of bridges: http://www.pbs.org/wgbh/nova/bridge/build.html

This Yes Mag website provides very simple background information and has also been included as a site to visit with the students in the 1st cycle. http://www.yesmag.ca/focus/structures/structures.html

Instructional Plan

Access Prior Knowledge

To get the students started, ask: *What kinds of structures have you or someone you know built?* (These could include bird feeders, garages, Lego buildings, bookshelves, and so on.)

Use a "think, pair, share" method to have students list 3 or more large structures, 3 or more small structures and 3 things that they aren't sure if they are structures or not. For this method, students generate their own lists first, share that list with a partner, and then share ideas with the whole class.

Make a class list or chart of ideas. Record these in a way that they can be revisited several times over the next series of lessons.

Accept all ideas and note any questions or conflicts of opinion that come up in the process. Questions/conflicting ideas can be recorded and put off to the side to see if students can revisit them and answer the questions later in the unit. The discussion tips on page 21-22 may help you encourage discussion.

> ✓ **Assessment:**
> Note the concepts and misconceptions students are expressing. You will need to know these to plan effective questions for subsequent activities and discussions so that students will examine and adjust their alternate conceptions.

Post student versions of curricular outcomes on chart paper (see page 24).

Inform students that these outcomes will be addressed over the next portion of the unit. Point out to students which outcomes are being addressed in each activity.

🚲 *1st Cycle*

✪ Curriculum Outcomes

101-10 Use appropriate tools to safely cut, shape, make holes through, and assemble materials
200-2 Identify problems to be solved
200-5 Identify materials and suggest a plan for how they will be used
201-2 Manipulate materials purposefully
201-3 Use appropriate tools for manipulating and observing materials and in building simple models
201-8 Follow given safety procedures and rules and explain why they are needed
202-8 Compare and evaluate personally constructed objects with respect to their form and function
203-2 Identify common objects and events, using terminology and language that others understand
203-5 Respond to the ideas and actions of others and acknowledge their ideas and contributions

Activity – Building Structures

The idea of having students build an initial structure is for students to have a structure to revisit and suggest improvements for.

Before starting, review any necessary safety rules such as using scissors, staplers, etc.

Materials:

Possible structural materials include:

straws; popsicle sticks; newspaper; toothpicks; paper towel or toilet paper rolls; egg cartons; yogurt containers; milk containers; boxboard

ⓘ Teacher note: We recommend you avoid using corrugated cardboard. We have found it is too difficult for students to cut and work with.

Possible joining materials include:

modelling clay; gum drops; tape; paperclips; pipe cleaners; cotton balls; styrofoam

Assign groups of students the task of building one of the following:

- a structure that is strong;
- a structure that is tall;
- a structure that crosses an open space;
- a structure that is a play/climbing structure; or
- a structure that can be used as a container.

Ideally, two groups should build the same type of structure to allow comparison of materials and structures built for the same purpose.

After the structure is complete, have each student fill in the “My First Structure” sheet (see page 13). Students in the same group may help each other with this task.

Tell them that they will be building another structure after doing some investigations so they should make very good notes of anything they had trouble with or would try if they had the chance to try it again. You may also wish to take digital photos of their structures at this time.

✓ **Assessment:**
During the student activity, make notes on outcomes (or parts of outcomes) you observe being addressed. Process skill outcomes are part of the curriculum and should be assessed. Using the observation chart or the checklist (see pages 31 to 33) on a clipboard may be helpful to you. Develop your own code for quick notes.

A suggested code:

√ observed and appropriate
WD with difficulty
A absent

This chart may be used on multiple days, using a different coloured pen or pencil each day and putting the date in the corner. You may not have a symbol or note for every child every day. Some teachers like to focus on a group or two each time. However you choose to make note of your observations, you will always have a sense of who you need to take more notice of and who might need extra support. The information will also help you when it is reporting time.

Reflection: Small Group Discussions

Have students meet with other groups to discuss what they built and to note how their structures are similar and different. Students could be asked to record their observations in a T-chart.

Similarities	Differences

1) Have students meet with one or two other groups that built the same kind of structure.

2) Have students meet with one or two other groups that built a different kind of structure.

Reflection: Class Discussion

Have students share their observations with the class.

Ask: *Did all of the structures look the same?*

How are they the same? How are they different?

Why do you think that happened?

Try to extend their observations to real life. *Where do we find these kinds of structures in real life? How are real structures the same and different from our structures?*

To introduce students to the variety and uses of structures that exist in the world, visit the website:

http://www.yesmag.ca/focus/structures/structures.html

This site http://www.toothpickcity.com/gallery/ features complex structures made from toothpicks.

Unusual houses and buildings can be found at http://www.roxanneardary.com/blog/unusual-architecture-from-around-the-world/

Revisit the Accessing Prior Knowledge activity (page 4). Ask: *Are there any items that should be added to or revised. Is there other information we could add?*

Remind your class about respectful discussion. The discussion tips on pages 21-22 may be helpful.

Reflection: Journaling

Now that you have attempted to build a structure, and talked to others who have built a structure, what building tips could you give to students in another class who are about to construct their first structure?

✓ **Assessment:**
Journal entries should not receive a score or mark. A positive comment followed by a question to refocus attention or suggest the next step in learning is very effective.

Note whether students can identify one or more things that worked well related to use of materials, how to join materials, and/or useful shapes for construction.

Think like a scientist

Asking good questions is an important skill in science. Initially students will need support. Model the skill with the whole class and students will begin to have the confidence to contribute. After some practice, students will be able to generate questions successfully individually.

Present students with a situation and ask them to generate questions that could be investigated scientifically. (These situations and questions do not have to be limited to those that can be done in a classroom.)

Information and pictures about the bike in this question can be found at: http://www.motorcyclemojo.com/articles/the-uno/

Situation:

> The Uno is a new type of motorized bike designed by an 18 year old Canadian. This structure first looks like one-wheeled cycle, but it actually is a two wheeled bike.
>
> What is one question concerning the Uno that could be investigated scientifically?

For example:

> How does a person make it go faster?
> How far can it go without being recharged?

My First Structure

Task:

<table>
<tr><td rowspan="2">Materials used:</td><td>My group:</td></tr>
<tr><td rowspan="2">Ideas for next time:</td></tr>
<tr><td>Problems encountered:</td></tr>
<tr><td colspan="2">Diagram(s) of structure:</td></tr>
</table>

🚲 2nd Cycle

✪ Curriculum Outcomes

100-34 Describe the properties of some common materials and evaluate their suitability for use in building structures
101-10 Use appropriate tools to safely cut, shape, make holes through, and assemble materials
200-5 Identify materials and suggest a plan for how they will be used
201-1 Follow a simple procedure where instructions are given one step at a time
201-2 Manipulate materials purposefully
201-3 Use appropriate tools for manipulating and observing materials and in building simple models
201-8 Follow given safety procedures and rules and explain why they are needed
202-5 Identify and suggest explanations for patterns and discrepancies in observed objects and events
203-2 Identify common objects and events, using terminology and language that others understand
203-3 Communicate procedures and results, using drawings, demonstrations, and written and oral descriptions
203-5 Respond to the ideas and actions of others and acknowledge their ideas and contributions

Before starting this activity, you could read The Three Little Pigs and talk about how different materials are used for different structures depending on what they will be used for.

The purpose of the activities below is to have students explore a variety of materials to determine their properties.

✋ Activities – Properties and Uses of Materials

Materials:

Various such as: straws; popsicle sticks; newspaper; toothpicks; paperclips; pipe cleaners; yogurt containers; milk containers; boxboard; cotton balls; styrofoam, and other recycled materials.

Task 1: Have students try to bend each material. Students should rank them from most difficult to easiest to bend. A written record should be made of the results.

Task 2: Next have students try to tear each material and rank them from most difficult to easiest to tear. Students need to record their results.

Task 3: From their lists, ask students to find one way to make the two most "bendable" materials less bendable, and the 2 most easily torn, tear-resistant.

> ✓ **Assessment:**
> On observation chart (or other record), note how students are performing on the skill outcomes.

Reflection: Class Discussion

Ask students*: What materials were the easiest to bend? Most difficult to bend? To tear?*

Remember that students do not necessarily have to agree, but they do have to be able to justify their conclusions with evidence. Allow students to respond to each other. Build a class chart of rankings. This is a good time to remind students that, like scientists, we can change our minds based on evidence.

Ask students to share how they made materials less bendable? Less easily torn?

If you were building something, what would the pipe cleaners be good for? The cardboard?

Are there examples in real life where materials are used in ways that will make them stronger?

For example : reinforced concrete has steel bars (see www.specialist-foundations.co.uk/reinconc.htm), corrugated cardboard has extra layer of cardboard (see http://en.wikipedia.org/wiki/File:Corrugated_Cardboard.JPG), decks have 2 or 3 pieces of wood all together to help support the load.

Revisit the "Think-Pair-Share" information created in the Accessing Prior Knowledge Activity (page 4). Remind students that scientific knowledge gets changed as scientists discover new things. Ask: *Are there any items that should be added to or revised? Is there other information we could add?* Remind your class about respectful discussion. The discussion tips on pages 21-22 may be helpful.

- Show students some of the interesting examples of strange buildings to illustrate different structures that use different materials depending on their purpose and the "look" they are trying to create. One site with a collection of pictures is www.unusual-architecture.com

Have students think about their first structure and fill in the materials part of the "My Next Structure" chart (student sheet, p. 17). In particular, students are to think about the materials they could use, why they chose them and how that would affect the look of their structure.

Reflection: Journaling

If you had to build a model of a wagon, what material would you use for the handle used to pull the wagon? Explain your choice.

✓ **Assessment:**
Journal entries should not receive a score or mark. A positive comment followed by a question to refocus attention or suggest the next step in learning is very effective.

Note whether students can defend their choice of materials for the wagon handle.

My Next Structure

Task:

Materials to use and why:	My group:
	Fasteners to use and why:
Diagram(s) of possible structure: Tell why you are using certain shapes.	

🚲 3rd Cycle

✪ Curriculum Outcomes

100-34 Describe the properties of some common materials and evaluate their suitability for use in building structures
101-10 Use appropriate tools to safely cut, shape, make holes through, and assemble materials
101-11 Investigate ways to join materials and identify the most appropriate methods for the materials to be joined
200-5 Identify materials and suggest a plan for how they will be used
201-1 Follow a simple procedure where instructions are given one step at a time
201-2 Manipulate materials purposefully
201-3 Use appropriate tools for manipulating and observing materials and in building simple models
201-8 Follow given safety procedures and rules and explain why they are needed
202-5 Identify and suggest explanations for patterns and discrepancies in observed objects and events
203-2 Identify common objects and events, using terminology and language that others understand
203-3 Communicate procedures and results, using drawings, demonstrations, and written and oral descriptions
203-5 Respond to the ideas and actions of others and acknowledge their ideas and contributions

✋ Activity – Joining Materials

Materials:

Straws, popsicle sticks, newspaper, toothpicks
Pipe cleaners, tape, paperclips, string, elastics, modelling clay, glue

Part I

Have students work in groups to explore how to join 2 straws at a single point.

Provide students with a variety of materials to test their usefulness in joining the straws. Students should use words and/or pictures to record their findings.

Next, ask students to join 3 straws then 4 then 5, still at a single point (materials may be side by side).

Part II

Ask different groups to try joining one of the following in 2s, 3s, 4s and/or 5s: popsicle sticks, newspaper, or toothpicks.

> ✓ **Assessment:**
> On observation chart (or other record), note how students are performing on the skill outcomes.

Reflection: Class Discussion

Have students share how they were able to join straws. Make a class chart.

Joining	Possible fasteners	Advantages and/ or disadvantages
2 straws		
3 straws		
4 straws		
5 straws		

There may be several possible fasteners for each kind of join. Have students discuss advantages and disadvantages of each joining method and add to chart.

Ask students: *What fastener do you think works best for joining each material used (e.g. straws, boxboard, yogurt containers, etc.)? Is there a best fastener?*

What materials might be good for joining something strong? Or tall? Or for a bridge?

Have students think about their first structure and fill in the fastener part of the "My Next Structure" chart. In particular, students are to think about the fasteners they could use, why they chose them and how that would affect the look of their structure.

Reflection: Journaling

If Michael wanted to build a windmill model, what material should he use and how should he join the materials? Explain your choices.

> ✓ **Assessment:**
> Journal entries should not receive a score or mark. A positive comment followed by a question to refocus attention or suggest the next step in learning is very effective.
>
> Note whether students can explain their choice of joining materials.

🚲 4th Cycle

✪ Curriculum Outcomes

100-34 Describe the properties of some common materials and evaluate their suitability for use in building structures
101-9 Test the strength and stability of personally built structures, and identify ways of modifying a structure to increase its strength and stability
101-10 Use appropriate tools to safely cut, shape, make holes through, and assemble materials
102-16 Identify shapes that are part of natural and human-built structures, and describe ways these shapes help provide strength, stability, or balance
200-5 Identify materials and suggest a plan for how they will be used
201-2 Manipulate materials purposefully
201-3 Use appropriate tools for manipulating and observing materials and in building simple models
201-8 Follow given safety procedures and rules and explain why they are needed
202-5 Identify and suggest explanations for patterns and discrepancies in observed objects and events
203-2 Identify common objects and events, using terminology and language that others understand
203-3 Communicate procedures and results, using drawings, demonstrations, and written and oral descriptions
203-5 Respond to the ideas and actions of others and acknowledge their ideas and contributions

Materials and Shapes Activity

Materials:

Straws; popsicle sticks; newspaper; tape; modelling clay; gum drops; toothpicks; paperclips; pipe cleaners; yogurt containers; milk containers; boxboard; cotton balls; styrofoam, and other recycled materials.

Have students explore materials, trying to create an arch, a square, a column and a triangle with each. Students should rank them from most difficult to easiest for making each shape.

As the students create their shapes, have them test each shape:

1) to determine how easy each is to bend (pushing on the top of the shape)
2) to crush (pushing on the sides of the shape)

Reflection: Class Discussion

Students will share their findings. There may be a lot of discussion. Allow students to respond to each other. Remind them about respectful discussion

- Have students share how they ranked the materials in terms of the easiest to shape.
- How did the students rank the materials in terms of the most resistant to crushing and bending?
- Were the materials that were easiest to shape the most resistant to bending and crushing?
- What shape seemed to stand up the best to being bent or crushed?
- Did everyone find the same results? If not, what did some groups do differently?

Look at shapes of natural and man-made structures to determine what shapes are used most. The following websites can be used to examine different structures:

This site has a huge variety of different structures. Pick a few of your favourites to examine shapes. http://www.terragalleria.com/pictures-subjects/buildings-and-structures/

The site "Structures in Nature" draws parallels between natural structures and manmade structures http://www.pennridge.org/works/structnat1.html

The Yes Mag website can be revisited to examine natural structures for shapes. http://www.yesmag.ca/focus/structures/structure_nature.html

Different bridge types are highlighted at http://www.pbs.org/wgbh/nova/bridge/build.html

Revisit the "My Next Structure" chart. Ask students to locate the diagram box and make a note of what shapes they would use if they had to build their first structure again. They should also attempt to draw the proposed structure.

Reflection: Journaling

You have been asked to build a model of a cell phone tower. Draw and label a picture of the shapes and materials you would use to create your 30 cm high tower. Explain why you have included those shapes in your structure.

✓ **Assessment:**
Journal entries should not receive a score or mark. A positive comment followed by a question to refocus attention or suggest the next step in learning is very effective.

Note whether students can explain their choice of materials and shapes.

Properties and Uses of Materials

1. For each material, try to bend it.
2. Make a list of the materials in order from most difficult to easiest to bend.

1. Repeat steps 1 and 2 trying to rip each material.

1. Take the two most easily bent items and find one way to make them less easily bent.

   I can make the _________ less easily bent by ______________.

   I can make the _________ less easily bent by ______________.

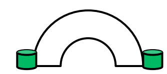
1. Repeat for the two most easily ripped materials.

   I can make the _________ less easily ripped by _____________.

   I can make the _________ less easily ripped by _____________.

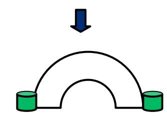
Materials and Shapes

1. For each material, make an arch. Help hold the arch in place by putting balls of clay or books on either side of the arch.

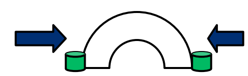


2. Make a list of the materials in order from most difficult to easiest to shape.

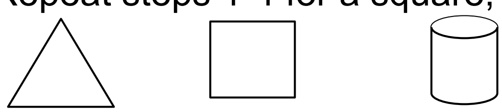
3. Next use your finger to push down on the top of the arch. Which material is the hardest to bend?



4. Now use your fingers to push in on the sides of the arch. Which material is the hardest to crush?



5. Repeat steps 1-4 for a square, a column and for a triangle.



Most difficult

Arch	Square	Column	Triangle

Easiest

🚲 5th Cycle

✪ Curriculum Outcomes

100-34 Describe the properties of some common materials and evaluate their suitability for use in building structures
101-9 Test the strength and stability of personally built structures, and identify ways of modifying a structure to increase its strength and stability
101-10 Use appropriate tools to safely cut, shape, make holes through, and assemble materials
101-11 Investigate ways to join materials and identify the most appropriate methods for the materials to be joined
102-17 Evaluate simple structures to determine if they are effective and safe, if they make efficient use of materials, and if they are appropriate to the user and the environment
200-2 Identify problems to be solved
200-5 Identify materials and suggest a plan for how they will be used
201-2 Manipulate materials purposefully
201-3 Use appropriate tools for manipulating and observing materials and in building simple models
201-6 Estimate measurements
201-8 Follow given safety procedures and rules and explain why they are needed
202-8 Compare and evaluate personally constructed objects with respect to their form and function
203-2 Identify common objects and events, using terminology and language that others understand
203-5 Respond to the ideas and actions of others and acknowledge their ideas and contributions

✋ My Second Structure Activity

Materials:

Straws; popsicle sticks; newspaper; tape; modelling clay; gum drops; toothpicks; paper towel or toilet paper rolls; egg cartons; paperclips; pipe cleaners; yogurt containers; milk containers; boxboard; cotton balls; styrofoam, and other recycled materials.

Provide students with the same materials as in the 1st Cycle. Each group will be given a specific type of structure with a very specific goal such as:

- A 1 meter tall free-standing tower that doesn't lean and doesn't fall over when fanned with air.
- A bridge that spans a 50 cm gap and can support 10 rolls of pennies.
- A container that can carry 1L of water without breaking

- A structure that is 20 cm wide on the base and can support 10 rolls of pennies.
- A playground structure with a 20 cm slide where 1 roll of pennies can roll down

Ask them to consult their structure notes on the “My First Structure” and “My Next Structure” sheets and plan out their new structures based on what they have learned from the other activities.

Students should complete the “My Second Structure” sheet (student sheet on p.27).

To test structures, you could set up a “Test” day with some excitement built around it such as prizes for everyone or the chance to chew gum while testing.

Discussion questions below can be addressed as each structure is tested. Remind your class about respectful discussion. The discussion tips on pages 21-22 may be helpful.

Reflection: Class Discussion

As each structure is tested, ask the following questions:
For all structures:

- *What material was used the most to create this structure?*
- *What shapes do you see?*
- *What types of joining materials are there?*
- *What do you predict? Will the structure meet the challenge?*

Did the structure meet the challenge/guidelines given?
If yes,

- *What made the structure successful?*
- *Was it a good use of materials (e.g. a reasonable amount of materials? Way too much of some materials?)*
- *Are there any suggestions for changes to make the structure “less expensive” or nicer to look at?*

If no,

- *What caused the structure not to work?*
- *What changes could make it achieve its design purpose?*

Reflection: Journaling

Revisit the “My Second Structure” chart. What would you change if you had to build this structure again?

✓ **Assessment:**
Journal entries should not receive a score or mark. A positive comment followed by a question to refocus attention or suggest the next step in learning is very effective.

Note whether students recognize how they could improve their structures.

Possible extension activity:

Create and build a newspaper geodesic dome which will hold an entire class.

A video showing how this could be accomplished is at http://www.yesmag.ca/projects/geodesic.html

My Second Structure

Task:

<table>
<tr><td rowspan="2">Materials used:</td><td>My group:</td></tr>
<tr><td rowspan="2">Test results:</td></tr>
<tr><td>Problems encountered:</td></tr>
<tr><td colspan="2">Diagram(s) of structure:</td></tr>
</table>

Alternative Investigation Based Lesson Plans

Grade 3 Science Curriculum - Knowledge Outcomes (Materials and Structures)		
100-34 Describe the properties of some common materials and evaluate their suitability for use in building structures	101-11 Investigate ways to join materials and identify the most appropriate methods for the materials to be joined	102-16 Identify shapes that are part of natural and human-built structures, and describe ways these shapes help provide strength, stability, or balance
101-10 Use appropriate tools to safely cut, shape, make holes through, and assemble materials	101-9 test the strength and stability of personally built structures, and identify ways of modifying a structure to increase its strength and stability	102-17 Evaluate simple structures to determine if they are effective and safe, if they make efficient use of materials, and if they are appropriate to the user and the environment

A One-Sided Paper Loop - The Möbius Band

Outcomes:
101-11 Investigate ways to join materials and identify the most appropriate methods for the materials to be joined
101-10 Use appropriate tools to safely cut, shape, make holes through, and assemble materials

Materials:
• Stripes of newspaper (about 5 cm wide, prepared ahead of time)
• Glue Sticks
• Student Scissors
• Marking Pens

Inquiry Lesson:

1. Show students a typical sheet of newspaper. Ask, “How many sides does this piece of paper have?” The expected answer is, of course, two. Next, cut a strip (about 5 cm wide) from the sheet of newspaper. Ask again “How many sides does this piece of paper have?” The answer again, is two. Cut another stripe and glue the ends together, making a simple loop. Ask, “How many sides does this loop have?” Then ask, “How do you know how many sides the loop has? Give each student group a loop to observe and handle, and allow them time to discuss and respond. Record student responses. Ask, “If paper has two sides, and I want to make a continuous line with my marker on both, what do I have to do with the marker?” Help students to see that you must pick up the marker at some point to make the a continuous line. Have them try this in their groups, first with a flat sheet of paper and them with the loop. Do students agree that the “pick up the marker” test work to determine two sides?

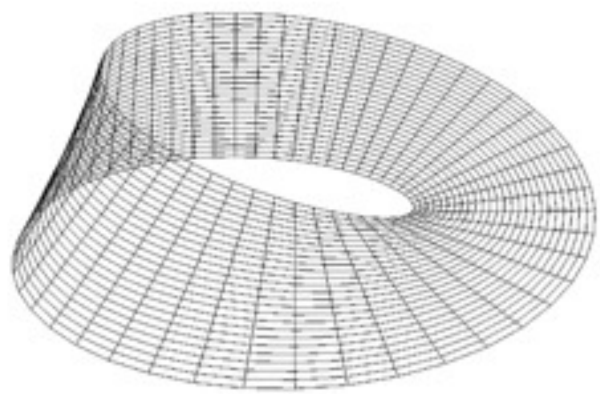
2. Next, in front of the students, cut another strip from the newspaper and make a loop, but turn one end of the strip so that the top faces down before gluing. That is, put a twist into the loop. Ask once again “How many sides does loop have?” Students are likely to answer, “two.” Ask, “How can we test for number of sides? Let’s try the pick-up-the-marker test. What do you think will happen?” Record their responses. Now demonstrate the pick-up-the-marker test (an extra pair of hands will be helpful here). Student will be surprised when you never have to lift the marker to make a continuous line on what appears to be two sides of the loop. Ask student for their reaction to this demonstration. Explain that this special loop is called a Möbius band, after its inventor, August Möbius, a 19th-century German astronomer and mathematician. Keep the marker band to use in Procedure 4.

3. Let each student group make several Möbius bands of their own. The activity proceeds more smoothly if you provide precut strips of newspaper or butcher paper. Encourage students to “explore” the band and to try the pick-up-the-

3. marker test themselves. Ask students "Is that what you expected? How do you explain this phenomenon?"

4. Return to your original Möbius band with the continuous line down the middle, used in procedure 2. Ask, "What do you think will happen if I take my scissors and cut along the line that I drew on this band?" Record student responses and then try it out. The results will be a loop with a double twist in it. Ask students, "How many sides does this loop have? How can we find out?" Hopefully, students will suggest the pick-up-the-marker test, which you can try. Students will see that the loop has two sides. Let students try this, too, with their own Möbius bands.

5. Referring to your double-twist loop constructed in Procedure 4, ask students about the possible outcomes, facilitating a range of options: "what will happen if I cut along the line I drew on this loop? What are some possibilities? One simple loop? A simple loop with a double twist? With a triple twist? A Möbius band? Two Möbius bands? A double loop? Any other possibilities you can think of?" Record student responses and then cut along the line. The result will be interlocking, twisted loops. Ask students, "Is either of these loops a Möbius band? Yes? No? How do you know?"



Discussion Questions:

1. How can you explain the fact that the Möbius band has only one side? Con you think of any other objects or shapes that have only one side?

2. How might a belt shaped like a Möbius band be more practical than a simple loop in a belt-driven machine? (Both sides wear out evenly, as opposed to one side only, thus lengthening the life of the belt and saving money.)

3. How is a cycle (such as the yearly seasons, the water cycle, or a plant's life cycle) similar to a Möbius band? How is it different?

Assessment:

1. Could students determine that while a simple loop has two sides, the Möbius band has only one? (Observe student during Procedures 3-5 as performance assessment, and at the same time, listen to their responses to Discussion Question 1 as embedded evidence.)

2. Were students able to test and explore their own Möbius bands? (Observe students during Procedures 3-5 as a performance assessment.)

3. Did students enjoy the activity? (as a form of embedded assessment observe student reactions as the activity progresses. Are students enthusiastic? Are they exploring on their own? What sorts of comments and questions are students coming up with in their groups?)

Rubric:

	Developing 1	Proficient 2	Exemplary 3
Could students determine that while a simple loop has two sides, the Möbius band has only one?	Attempted to explain but unable to do so	Explained and used the concept in Procedure 4 but unable to apply it in Procedure 5	Explained and using the concept effectively in Procedures 4 and 5
Were students able to test and explore their own Möbius bands?	Explored but did little or no testing	Explored and tested their bands	Explored, tested, explained, and discussed their bands effectively
Did students enjoy the activity?	Enthusiastic by no particularly well engaged in the activity	Enthusiastic and engaged in the activity	Enthusiastic, thoroughly engaged and anxious to apply and discuss the activity

Making a Book Holder

Outcomes:
101-10 Use appropriate tools to safely cut, shape, make holes through, and assemble materials
101-9 test the strength and stability of personally built structures, and identify ways of modifying a structure to increase its strength and stability

Materials:
• A few sheets of paper
• Textbook
• Tape
• Scissors

Inquiry Lesson:
1. Present students with a Challenge: **to manipulate the paper any way so that it is capable of holding a book 2 inches off the desk for 10 seconds.** Specifically they can cut, roll, bend. twist, rip, crinkle, and crumple the paper. It is suggested that the teacher demonstrate how the book would be held off the desk so students get a visualization of what is expect. It should be noted that the teacher should not demonstrate how the suspend the book with paper.
2. Students time should be broken down into 3 different intervals:
    1. Planning Time
    2. Practice Time
    3. Official Testing Time

3. Planning time should be limited to no more than 5 minutes. This planning time should be free of the materials so that students cannot get distracted during this time. It is very important that student groups create as many different prototypes and engage in discussion to design the blueprints of their designs.

4. Students and teacher should agree to the amount of time that will be given to both Practice time and Official Testing time. These times should be relatively similar. Also, it should be emphasized to students that practice time is dedicated to just testing different prototypes and they should be encouraged to build the best structure possible. Students should be aware that no designs will be tested until Official Testing time begins.

5. Practice time is an open inquiry time to test their initial prototypes and blueprints. Give students the materials: paper, book, tape, scissors. During this time students will retest and refine their initial designs and modify them. Students should be encouraged to test as wide a variety of tower designs as possible to find the one with the greatest potential. For younger students, allow more practice time and be willing to help with design ideas.

6. When students are encountering problems with construction, offer guidance rather than offering solutions. For example, ask students,
    - What do you need to keep it in balance?
    - Do you need to cut the paper?
    - Do you need to crinkle the paper?

7. When official testing time begins students should be given new paper and tape to create the best possible holder for their book. Students are not limited to just one opportunity to perform this activity. Students should be reminded that this is not a competition between groups, rather this is an opportunity for each groups to be successful at completing the task. Each group will be given as many opportunities to be timed by the teacher.

8. Conclude with a class wide discussion and analysis of the activity, including a presentation of each of the designs constructed. Ask students,
    - What would you do differently next time?
    - What did you enjoy about this activity?
    - What would you like to know about towers?

Discussion Questions:

1. Which design worked? Which didn't? How do you explain these results?

2. How important were measurements in this activity? Explain your answers.

3. What sort of training do you think a person would need if he or she wanted to design and build structures in real life?

Assessment:

1. Were students actively involved in building and analyzing the design of free-standing book holders? (Use observations made during Procedures 5-7 as performance assessments, and use responses to Discussion Question 1 as an embedded assessment.)

2. Could students identify and communicate about successful and unsuccessful strategies, shapes, designs, and patterns related to construction of the book holder? That is, were they able to draw effective conclusions about their designs? (Use student responses to Discussion Question 1 as embedded assessments or as writing prompts for science journal entries.

Rubric:

	Developing 1	**Proficient 2**	**Exemplary 3**
Were students actively involved in building and analyzing the design of free-standing book holders?	Unsuccessfully attempted to design and construct a book holder	Successfully designed and constructed a book holder	Took a leadership role in the successful design of their team's structure
Were students able to draw effective conclusions about designing book holders?	Attempted to draw significant conclusions about structural design, but were unable to do so	Draw several significant conclusions about the design of their own structure	Clearly explained and discussed several significant conclusions about their own and others structural designs

The Tower Challenge

Outcomes:
102-16 Identify shapes that are part of natural and human-built structures, and describe ways these shapes help provide strength, stability, or balance
101-9 test the strength and stability of personally built structures, and identify ways of modifying a structure to increase its strength and stability

Materials:
• 2 Different colors of standard 8.5 x 11 inch paper
• Masking Tape
• Meter sticks
• Scissors

Inquiry Lesson:
1. Brainstorm with students. Start by asking,
    - What towers have you seen or visited?

   Consider famous towers (e.g., Eiffel Tower, Leaning Tower of Pisa), skyscrapers, radio transmission towers, and natural towers. Point out to students that all "towers" are not necessarily architectural; for example, the long bones of the body such as the humerus and the femur are essentially towers, too. Ask,
    - What do towers have in common?
    - How are they constructed?
    - If they notice different varieties, how would you categorize them?

   Leave the brainstormed list on the board during the activity to prompt speculation, experimentation, and creativity during the tower construction. Be sure that students are considering a wide range of geometric options (in terms of the cross-sectional and vertical shapes of their towers) as they evaluate possible designs.

2. Tell students that you are challenging them to build their own towers in class. The challenge is this: **Build the tallest free-standing tower possible from a single piece of paper and 30 cm of masking tape.**

3. Present the following ground rules:

- Your group's final tower may only contain those materials (paper and tape) supplied by the teacher.
- The tower must not be attached at the base to any surface (e.g., desk, floor) and may not lean against any other surface.
- You will have 30 minutes for official design and construction.
- Your tower must stand on its own for 10 seconds or longer.
- The height will be measured from the base to the highest point.

- You can have your tower "officially" measured as many times as possible within the 30 minute time limit; that is, you can keep adding to it as time permits.

4. The following scoring plan pits students only against gravity and eliminates any overt or unnecessary competition between groups.
   - Over 50 cm = Good
   - Over 80 cm = Outstanding
   - Over 100 cm = Spectacular
   - Over 150 cm = A Masterpiece of Engineering and Design!

5. Tower-building time should be broken into two sections: practice time and official time. Practice time will last for 30 minutes. Student groups receive several pieces of paper, scissors, 30 cm of masking tape, and a meter stick to check their progress. Ask and brainstorm,
   - What possible shapes or designs could you use?

   Students should be encouraged to test as wide a variety of tower designs as possible to find the one with the greatest potential. For younger students, allow more practice time and be willing to help with design ideas.

   Keep in mind that air conditioning, open doors, and/or open windows can create breezes that will topple towers and frustrate participants during this activity.

6. Official tower time begins when practice period ends, and lasts for another 30 minutes. Be sure that students surrender any extra paper and tape left over from practice time. You could take a break between the two periods to discuss practice efforts, likely structural candidates, and so on. This discussion would allow students to hypothesize about the tower designs that are most likely to meet the challenge. Or, to encourage separate efforts by the student construction groups, you could dispense with the discussion, moving directly from practice into official time.

7. When official time begins, student groups should receive a single sheet of paper and another 30 cm of tape. To make sure that practice paper is not accidentally incorporated into official towers (thus providing extra construction material), use two different colors of paper, one for practice and one for the official tower. With a list of student groups in hand, circulate and verify student tower height measurements whenever students ask, documenting their progress on the list. They may continue to add to their towers throughout the time period, so some groups may ask to be officially measured more than once.

8. Conclude with a class wide discussion and analysis of the activity, including a presentation of each of the towers constructed. Ask students,
   - What would you do differently next time?
   - What did you enjoy about this activity?
   - What would you like to know about towers?

Extension:

1. Have students conduct research (e.g., library, internet, interviews) into various towers of interest: strange towers, tallest towers, towers in history, most beautiful towers, and so on.

2. Instruct students to build a paper model of a real tower (e.g., skyscrapers, radio tower, Eiffel Tower, CN Tower, Leaning Tower of Pisa). this could be done on an individual basis, by cooperative groups, or by the entire class.

Discussion Questions:

1. Which design worked? Which didn't? How do you explain these results?

2. What geometric shapes do you see in the completed towers? (Consider the towers in cross section as well as in lateral view.) What other shapes did you experiment with? Why do you suppose that certain shapes work better then others in tower design?

3. How important were measurements in this activity? Explain your answers.

4. How did your completed towers compare with the real towers we listed on the chalkboard? How were your towers similar to those? How did they differ?

5. What sort of training do you think a person would need if he or she wanted to design and build real towers?

Assessment:

1. Were students actively involved in building and analyzing the design of free-standing paper towers? (Use observations made during Procedures 5-7 as performance assessments, and use responses to Discussion Question 1 as an embedded assessment.)

2. Were students able to recognize geometric shapes in their tower designs? (Use Discussion Question 2 as embedded evidence or as a prompt for a science journal entry.)

3. Were students able to measure accurately? (Use observations made during Procedures 5 and 7 as a performance assessment, and use responses to Discussion Question 3 as an embedded assessment.)

Rubric:

	Developing 1	Proficient 2	Exemplary 3
Were students actively involved in building and analyzing the design of free-standing paper towers?	Only marginally involved with tower design, construction, and analysis	Appropriately and significantly involved in tower design, construction, and analysis	Took a leadership role in tower design, construction, and analysis
Were students able to recognize geometric shapes in their tower designs?	Unsuccessfully attempted to identify geometric shapes in their tower designs	Recognized several geometric shapes in their own tower design	Recognized geometric shapes and could explain their impact on tower design
Were students able to measure accurately?	Unsuccessfully attempted to measure tower height	Successfully measured tower height	Successfully measured several aspects of tower design
Were students able to explain similarities and differences between real towers and their own paper towers?	Unsuccessfully attempted to explain similarities and differences between real towers and their own to any extent	Successfully explained several similarities and differences between real towers and theirs	Successfully explained similarities and differences and were also able to explain their implications for tower design and construction

Designing and Constructing a Load-Bearing Structure

Outcomes:
101-9 test the strength and stability of personally built structures, and identify ways of modifying a structure to increase its strength and stability
102-17 Evaluate simple structures to determine if they are effective and safe, if they make efficient use of materials, and if they are appropriate to the user and the environment

Materials:
• Various wire materials: pipe cleaners (two different colors) and/or actual wire (copper wire, baling wire, galvanized wire, steel wire, thick wire, thin wire, etc.)
• Wire Snippers (several pairs)
• Pliers (several pairs)
• Art books with photos of sculpture and/or actual pieces of sculpture
• Photos or Illustrations of Towers
• Lots of pipe cleaners (at least 15 per student group, of various colors if possible)
• Scissors
• Metric Ruler
• Lots of pennies
• Plastic cups
• Balances/Scales

Inquiry Lesson:

1. Begin the activity with an open exploration of wire as a medium for sculpting. Offer the students various wiry materials: pipe cleaners (various colors, if possible) and/or actual wire (of varied thickness, or gauge). If you do choose to include wire, you can find it in your hardware store i a wide variety of forms: copper wire, baling wire, galvanized wire, steel wire, thick wire, thin wire, and so on. If you use wire, you'll also need some pliers and snippers. Pipe cleaners can be cut using scissors, Thin wire is easier (and therefore safer) to bend, cut, and manipulate. Demonstrate to students that by twisting the wire together it can be formed into nearly any shape. Ask them to use their imagination to decide what they would like to create. Show some photos of sculptures to stimulate their imaginations. You might ask all students to sit with their eyes closed, take a few calming breaths, and visualize their sculptures. Them let everyone get busy making a boat, a car, a building, an their interpretations of an abstract concept (such as "knowledge" or "peace") or a personal feeling. Compare and discuss the projects when completed, Ask students what they like about sculpting with wire and how they feel about their creations.

2. Ask students,

- Can you think of some structures that have a bear weight?

Possible answer might include the wooden frame of a house, a table, the human femur bone, a ladder, a column, the steel girders in a skyscraper, a tree trunk, and so on. Photos and/or illustrations would be helpful here. Students could even draw their own pictures of some of the structures. Generate and record as many responses as possible. Ask,

- What characteristics do all these load-bearing structures have in common?
- How do they differ?
- What do you notice about their shapes?
- Are there any ways in which their shapes are different?
- How does the structure of something that must bear a relatively heavy load differ from that of somethings that must only support a light load?

3. Explain tot he class that student groups will design and build their own load-bearing structures out of pipe cleaners. **The challenge is this: Can each group design and build a structure that will hold a plastic cup containing 50 pennies at least 10 cm off the table top, using nothing but 10 pipe cleaners?** Explain that there will be a class-wide competition for the structure that can hold the most pennies at least 10 cm off the table top. The following ground rules should be explained and discussed to make sure that the students understand:

- You may not use any materials other than the pipe cleaners, but you don't have to use all 10 if you don't need them.
- Your structure may not be attached to the table and may not touch or lean against anything but the table.
- The structure must support the cup of 50 pennies for at least 10 seconds, which the referee must time.
- You will have 30 minutes for trial-and-error "design time" and 45 minutes to construct the "official" structure. You'll get 5 "trial-and-error" and 10 "official" pipe cleaners. (It's a good idea to make sure that the two sets of pipe cleaners are different colors to eliminate accidental mixing of extra materials into the official structure.)

4. Each group should receive 5 practice pipe cleaners, a cup with a sealed bag containing pennies, a metric ruler, and a pair of scissors. Give students 30 minutes to plan their structure, encouraging each group to brainstorm together and consider a range of possible designs. An important part of this process will be to consider the geometric aspects of the design possibilities; for instance, what are the advantages of various shapes, including square, rectangle, triangle, or column? Remind students that in a brainstorming session the idea is to generate as many ideas as possible without judging them as good or bad. The final design is then chosen from that list of ideas. Suggest that they sketch potential structural plans on paper before actually building.

5. When the practice time is up, give each group the 10 official pipe cleaners and let them begin creating their final structure. Circulate among groups and offer encouragement, but only offer design suggestions to alleviate especially high frustration levels. Don't offer too much help; this exercise allows students to develop their own means of problem solving, and too much teacher assistance will diminish

5. that process. Test each group's structure for its 50-penny-supporting capability as requested. Be sure that each group has a structure to enter in the class-wide competition.

6. When the 45-minute time period is up, ask all groups to stop work and to gather around for the competition. Take one structure at a time and test for tis ability to support the cup of pennies. Keep adding pennies (in increments of 10) until only one structure remains. How many pennies could it hold before it collapsed? Weigh the pennies to find out how many grams they represent. Engage the class in a discussion of successful and unsuccessful shapes, design, and patterns. Explore the conclusions that can be drawn about the effective design of load-bearing structures.

7. If time and student interest permit, allow groups to confer as you re-challenge them for a second try at building a strong load-bearing structure. Often the second time around, using the same rules, procedures, and materials, is when many students really "get it."

Extension:

1. Explore ways to make more wire sculptures. Students should consider making wire mobiles and/or creating sculptures that go along with a favorite book or story. Also encourage students to try making geometric/arithmetic sculptures (e.g., all triangles, or using squares of increasing sizes).

Discussion Questions:

1. Why do load-bearing structures need to be designed carefully?

2. How is mathematics important in designing/engineering load-bearing structures? For instance, what patterns or shapes were useful and how did you identify them?

3. Which load-bearing design are also aesthetically/artistically pleasing? That is, is art important in designing/engineering load-bearing structures? Why? Under what circumstances would be aesthetic appearance of such a structure become important?

4. What else would you like to know about load-bearing structures? How could you find answers to your questions?

Assessment:

1. Where student groups able to successfully design and construct their own load-bearing structures out of pipe cleaners? (Use observations made during Procedures 3-6 as performance assessments.)

2. Could students identify and communicate about successful and unsuccessful strategies, shapes, designs, and patterns related to construction of load-bearing structures? That is, were they able to draw effective conclusions about designing load-bearing structures? (Use student responses to Discussion Question 1-4 as embedded assessments or as writing prompts for science journal entries.

Rubric:

	Developing 1	Proficient 2	Exemplary 3
Were student groups able to successfully design and construct their own load-bearing structures out of pipe cleaners?	Unsuccessfully attempted to design and construct a load-bearing structure	Successfully designed and constructed a load-bearing structure	Took a leadership role in the successful design of their team's structure
Were students able to draw effective conclusions about designing load-bearing structures?	Attempted to draw significant conclusions about structural design, but were unable to do so	Draw several significant conclusions about the design of their own structure	Clearly explained and discussed several significant conclusions about their own and others structural designs