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GRADE 7 – Bridge Over the River
Note: Review the following four approaches before beginning as they were designed to work most effectively when used interdependently and sequentially.

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An Anticipation Guide is a series of questions or statements related to the topic or point of view of a particular text. Students work silently to read and then agree or disagree with each statement. In the case of structures, students need to understand concepts like forces, structural stability and reasons for structural failure. In “Factors that Affect Structural Design”, students will read about these concepts in relation to ordinary objects. The statements and questions presented in the Anticipation Guide will help students consider some of the key concepts about structures they apply in this unit.

**Purpose**
- Help students to activate their prior knowledge and experience and think about the structure ideas they will be reading.
- Encourage students to make a personal connection with concepts in structures so that they can integrate new knowledge with their background experience and prior knowledge.

**Payoff**
Students will:
- connect personal knowledge and experience to their understanding of the concept of structures.
- engage with ideas on engineering structures at their current level of understanding.
- have a purpose for reading related text.
- become familiar and comfortable with topics in engineering before reading unfamiliar text.

**Tips and Resources**
- This anticipation guide may contain unfamiliar information regarding engineering structures. The idea of the guide is to raise students’ awareness of the topic and help them make connections with what is familiar and unfamiliar about that text.
- The questions in this guide are designed to help students relate the concepts of structures to everyday structures and objects. The questions provoke thought about why structures are made as they are, and how they can design structures using basic principles in engineering design.
- This activity is provided for teaching the Grade 7 Science and Technology unit on Structures, Strengths and Stability. See Student/Teacher Resource, Factors Affecting Structural Design: Reading Package.
- For more information see Think Literacy: Cross-Curricular Approaches, Grades 7-12, pp.20-21.
- To connect these activities to course expectations, technological literacy benchmarks and employability and innovation skills see Teacher Resource, Key Standards for Getting Ready to Read: Anticipation Guide.

**Further Support**
- Put students in pairs to complete the anticipation guide if they are having trouble making connections with the theme or topic, or if they are having trouble with the language of the text.
- ESL students may benefit from pairing with a partner who speaks the same first language so they can clarify concepts in their first language.
- To provide an opportunity for struggling students to contribute in a more supportive situation, divide the class into small groups of four or five and ask them to tally and chart their responses before participating in a whole-class discussion.
- Read statements aloud to support struggling readers.
<table>
<thead>
<tr>
<th>What teachers do</th>
<th>What students do</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before</strong></td>
<td><strong>During</strong></td>
</tr>
<tr>
<td>• Determine reading group arrangements for students: pairs or small groups.</td>
<td>• Read <em>Factors Affecting the Design of a Structure - Reading package</em>, and jot down page numbers beside each agree/disagree statement (for information that relates to each statement).</td>
</tr>
<tr>
<td>• Gather six sets of the following materials for students to share:</td>
<td>• Contribute responses to the class discussion and explain them.</td>
</tr>
<tr>
<td>- 8 children's alphabet blocks,</td>
<td></td>
</tr>
<tr>
<td>- 3 Jenga children’s blocks (8.0 cm x 2.5 cm x 1.5 cm),</td>
<td></td>
</tr>
<tr>
<td>- 1 empty pop can.</td>
<td></td>
</tr>
<tr>
<td>• Distribute copies of the <em>Anticipation Guide: Factors Affecting the Design of a Structure</em>. Explain that this is not a test, but an opportunity for them to explore their own thoughts and opinions. Students first complete the guide individually and then share their thoughts in a whole-class discussion.</td>
<td></td>
</tr>
<tr>
<td>• To engage the class in a whole-class discussion, start with a simple hand count of the numbers of students who agreed or disagreed with a particular statement. Then ask the students who disagreed to share their thinking, followed by those students who agreed with the statement.</td>
<td></td>
</tr>
<tr>
<td>• Record (or ask a student to record) some of the key points made during the discussion, using a “T-chart” (agree/disagree) on the board or an overhead.</td>
<td></td>
</tr>
<tr>
<td>• Ask students to keep the guide beside the text as they read it, so that they can jot down the page numbers that correspond to each statement.</td>
<td></td>
</tr>
<tr>
<td><strong>After</strong></td>
<td></td>
</tr>
<tr>
<td>• Ask students to return to the statements and to make notes from what they have discovered in their reading that may confirm or change their opinions.</td>
<td>• Make notes from what they have discovered in their reading that confirmed or changed their opinions about the statements.</td>
</tr>
</tbody>
</table>

- Circle “Agree” or “Disagree” beside each statement below before you read the hand-out package on structural design.
- Following the class discussion of these statements, read Factors Affecting Structural Design Reading Package, noting the page number that relates to each statement.
- When you have finished, consider the statements again based on any new information you have read. Circle “Agree” or “Disagree” beside each statement and check to see whether your opinion has changed based on new evidence.

<table>
<thead>
<tr>
<th>Before Reading</th>
<th>Statements</th>
<th>Page #</th>
<th>After Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Agree / Disagree</td>
<td>Designers create new things to make because people have a need for something new.</td>
<td></td>
<td>Agree / Disagree</td>
</tr>
<tr>
<td>2. Agree / Disagree</td>
<td>A structure is stable if it is made with good materials.</td>
<td></td>
<td>Agree / Disagree</td>
</tr>
<tr>
<td>3. Agree / Disagree</td>
<td>It is easier to sink a nail in wood with a bunch of small taps than one hard strike.</td>
<td></td>
<td>Agree / Disagree</td>
</tr>
<tr>
<td>4. Agree / Disagree</td>
<td>A pyramid can’t fall over.</td>
<td></td>
<td>Agree / Disagree</td>
</tr>
<tr>
<td>5. Agree / Disagree</td>
<td>Football players in a three point stance (crouched position) are harder to knock over than when they are standing straight up.</td>
<td></td>
<td>Agree / Disagree</td>
</tr>
<tr>
<td>6. Agree / Disagree</td>
<td>It is very difficult to tip a table when you push it.</td>
<td></td>
<td>Agree / Disagree</td>
</tr>
<tr>
<td>7. Agree / Disagree</td>
<td>Only people and animals are affected by stress.</td>
<td></td>
<td>Agree / Disagree</td>
</tr>
<tr>
<td>8. Agree / Disagree</td>
<td>A steel beam is stronger than one made of wood.</td>
<td></td>
<td>Agree / Disagree</td>
</tr>
</tbody>
</table>
Factors Affecting Structural Design: Reading Package

Computers, chairs, bridges, houses, umbrellas and towers are all examples of structures. There are three types of structures:

- **Shell** - solid surface and hollow interior (i.e., toolbox, roof)
- **Mass** - only one part, solid form (i.e., dam, road)
- **Frame** - made with a combination of parts that could not support a force individually (i.e., tower, bridge)

**Needs**: Designers are always designing new structures to meet a need. Some needs might be to help us work faster, to make lives more pleasant or perhaps to perform a dangerous task such as collecting rocks on Mars.

**Considerations**: A bridge that can’t hold the heavy traffic crossing it is dangerous, while a computer tower that tips too easily is frustrating. To prevent designing something incorrectly, designers must consider many things. Some of these considerations would be:

1) What forces will be acting upon the structure (gravity, weather, etc.)?
2) How will the structure impact the environment?
3) What materials are available?
4) What will be the cost of the finished structure?

To be good designer it is necessary to know what forces can be expected to act upon your design and how will these affect the structure.

**Center of Gravity and Stability Working Together**

**Stability**: A structure is stable if it remains on its base undamaged. The stability of a structure depends on the materials the structure is made from and how its mass is distributed.

**Center of Gravity**: All structures are affected by gravity. In every object, there is a point where the mass of the object is concentrated. This is called the CENTER OF GRAVITY. When you support an object at this point it will stay perfectly balanced.

**Activity #1**: Using a book, try to balance it on one finger. Can you find the center of gravity? Where is it located?
Factors Affecting Structural Design (continued)

Center of Gravity and Stability Working Together

*Activity #2:* Stack 8 blocks on top of each other. Then using 8 more blocks stack them as in the diagram on the right.

Which tower would be easier to tip? You will notice the tall, slender tower tips easily while the broader tower will not. There are two reasons for these results:
- Widening a base will provide more stability.
- Lowering the center of gravity will increase stability.

Looking at the diagrams below, you can see why pyramids have been standing for so many years. Football players know they are harder to knock down when they are in a crouch position.

**Forces:** Have you ever had a ride in a bumper car? Why does every crash provide a variety of results? The answer is all crashes are not the same. The effects of a force depend upon its:
- magnitude
- direction
- point of application
Factors Affecting Structural Design (continued)

Magnitude of Force: Magnitude is the measure of how strong a force is. You have probably noticed that if you gently tap on a nail, it will not go into a piece of wood very far. The tap is low magnitude.

A hard strike on a nail head will give more success. This strike is high magnitude.

Activity #3: Using the blocks provided, you can see how magnitude affects a structure. Arrange the 3 long blocks as in the diagram below. Gently push with your finger and you will see the blocks will remain standing. Push again, increasing the magnitude of your force on the object. What eventually happens?

Direction of Force: The direction of force will also affect a structure. If you “push” on a door that says “pull”, it will not open.

Activity #4: Set the blocks up again as in the diagrams. Gently push with the same magnitude of force a little at a time. What eventually happens to the structure? The same thing will happen if a poorly-designed and poorly-constructed tower is exposed to years of high winds.
Factors Affecting Structural Design (continued)

**Point of Application of Force:** Have you ever pushed a chest of drawers? If you push low on the chest, it will slide. If you push too high on the chest, it will tip.

**Activity #5:** Try this test. Place a pop can on a smooth surface. Using a pencil, push against the can to slide the can along the table. See Diagram A below. What happens to the can?

Now repeat the test pushing with the pencil as shown in Diagrams B and C. What happens to the can in each case?

![Diagram A](image1)

![Diagram B](image2)

![Diagram C](image3)

Materials play an important part in building a structure. A tower made with steel beams would be stronger than one built with cardboard.

When a designer is ready to have a structure built, for example, a tower, he/she will work with engineers to decide which type of beam designs would be best to use. Beams come in many different shapes such as tubular (round), triangular, and rectangular. Some are solid while others are hollow. Each type of beam will react differently to different measures of force.

Choosing the wrong materials could create a disaster resulting in severe injury or even death to people using the structure.
Factors Affecting Structural Design (continued)

How Loads Affect a Structure

When a designer creates a structure, he must consider the loads that will be applied to that structure. An adult’s bike that can only hold the weight of a tiny child is not very useful. A structure must be able to withstand many factors such as stress and changing loads.

**Load:** Many things can make a LOAD - wind, ice, rain, cars, even people. There are two types of loads:
- STATIC loads which are caused by gravity.
- DYNAMIC loads which are caused by forces other than gravity.

There are two types of static (gravity) loads. When you ride a bike, the bike has gravity pulling on it. Because the load stays the same it is called a DEAD load. You, the passenger, are the LIVE load. The live load changes with each rider. A designer must keep in mind how the structure will be used and any loads that will be placed on it.

Forces other than gravity cause DYNAMIC loads. For example, potholes in the road or the wind are constantly changing and placing different sized loads on the bike. Dynamic loads change frequently with road and weather conditions.

**Stress:** When a load is put on a structure it can cause compression, twisting and bending. These are called STRESS FACTORS.

**Tension and Compression:** As you walk along a beam it will bend. You are the load. The bottom of the beam is stretched and pulled in tension while the top squeezes and is pushed together, causing compression.
Factors Affecting Structural Design (continued)

**Torsion:** is a stress caused by twisting motion. As you wring out a dishcloth, you are causing the threads to twist. If you do this long enough it will wear out.

**Shear:** When two parallel forces act in opposite directions, they can cause shearing or tearing motion. If you pull 2 pieces of liquorice apart you create a shearing force.

**Symmetry:** The next time you look in a mirror, look closely and you will see that the right and left side of your face look very much alike. Your features are symmetrical which means one-half is the mirror image of the other half.

Symmetry is common in nature. Designers know that symmetry is also important in designing structures. Symmetry improves the stability of a structure. Imagine a chair if it was not designed symmetrically. Can you imagine what would happen to the following chair design when force is applied?

Symmetrical structures are easier and usually less expensive to build. For example, a tall office building built using symmetry will repeat the same design. The windows would all be the same shape making it cheaper to buy windows in quantity. Repeating the same sections over and over make the building easier and faster to complete.

All these factors are important for designers to consider when designing a structure. They will be important for you to consider when you design a structure too!
Key Standards For Getting Ready to Read: Anticipation Guide

This activity is based on the following course expectations, technological literacy benchmarks and employability and innovations skills. These are to guide the teacher in developing assessment strategies and as a tool to illustrate the importance of the activity on developing a student's future career potential.

References
The Ontario Curriculum, Grades 1-8 Science and Technology (1998)
International Technology Education Association (ITEA) Standards for Technological Literacy, Content for the Study of Technology (2000)
Conference Board of Canada Innovation Skills Profile (2002)

Course Expectations
Structures and Mechanisms: Grade 7 - Structural Strength and Stability

Overall Expectations
By the end of Grade 7, students will:
SOV1 demonstrate an understanding of the relationship between the effectiveness of structural forms and the forces that act on and within them;

Specific Expectations
SC3 describe, using their observations, ways in which different forces can affect the stability of a structure (e.g., certain forces may cause a structure to shear, twist, or buckle);
SC4 demonstrate awareness that the effect of forces acting on a structure under load depends on the magnitude, direction, and point and plane of application of the forces;
SC5 identify forces within a structure that are affected by forces outside the structure (e.g., shear, torsion, tension, and compression within a bridge are affected by external forces such as high wind or ice);
SR7 describe, using their observations, the function of symmetrical design in structural and mechanical systems (e.g., in bridges).

ITEA Technological Literacy Benchmarks
Standard 1: The characteristics and scope of technology
G: The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative.
Standard 2: The core concepts of technology
N: Systems thinking involves considering how every part relates to others.
S: Trade-off is a decision process recognizing the need for careful compromises among competing factors.

Conference Board of Canada Employability Skills
Communicate
CBC1 read and understand information presented in a variety of forms (e.g., words, graphs, charts, diagrams)
CBC3 listen and ask questions to understand and appreciate the points of view of others

Conference Board of Canada Innovation Skills
Creativity and Continuous Improvement Skills
IS1. Ask questions to assess situations, identify problems, and seek solutions
IS2. Look for surprising connections - be open-minded when exploring possible solutions
Visualizing ideas in defined design challenges is essential for arriving at possible solutions. It is an invaluable technique in understanding engineering terms and concepts that may be unfamiliar to students. Concepts such as load bearing, stress, strain, plasticity or elasticity can be better understood if the student is encouraged to visualize related concepts from their own personal experience. Spatial dimensions, such as length, height or other measures such as weight or speed may also be better understood when the student can compare visually to shared experiences (e.g., How many students does it take linked together to reach 20 metres?).

**Purpose**
- Promote comprehension of engineering ideas in written texts by forming pictures in the mind from words on the page.

**Payoff**
Students will:
- conceptualize important engineering and metrological concepts.
- develop skills for independent reading.
- improve focus and attention to detail.
- improve conceptualization of design ideas.

**Tips and Resources:**
- Engineering terms and concepts can be very abstract, particularly if they have to be applied to solving a design challenge. In designing structures, one must understand such higher-level concepts as thrust lines, compression or tension. Also, students may have difficulty in interpreting stated dimensions such as length or weight. These concepts can be taught by helping students make mental pictures of the words they are reading.
- In order to understand the engineering concepts of structures, it would help to have visual aids and manipulatives, such as building or modeling materials, and pictures of structures such as towers and bridges.
- To connect these activities to course expectations, technological literacy benchmarks and employability and innovation skills see Teacher Resource, *Key Standards for Engaging In Reading: Visualization.*

**Further Support**
- Learning to visualize takes practice. Model the strategy of visualizing for your students, using a variety of texts from the subject area.
- Put students in pairs from the beginning of this strategy and allow them to work through the texts together.

*Think Literacy: Cross Curricular Approaches, Grades 7-12*, pp. 56-57.
## Engaging in Reading: Visualizing

### Science and Technology Grade 7 (Structures and Mechanisms)

<table>
<thead>
<tr>
<th>What teachers do</th>
<th>What students do</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before</strong></td>
<td></td>
</tr>
<tr>
<td>• Prepare and distribute design brief and reading materials. (See Student Resource, <em>Bridge Over the River – Design Brief.</em>)</td>
<td>• Visualize and discuss their prior knowledge and experiences of bridge structures.</td>
</tr>
<tr>
<td>• Engage students in a class discussion on the concepts of bridges and ask students to consider bridges they have seen or experienced. Invite students to share their stories.</td>
<td>• Listen actively and critically to understand and learn.</td>
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<tr>
<td></td>
<td>• Participate in class discussions.</td>
</tr>
<tr>
<td><strong>During</strong></td>
<td></td>
</tr>
<tr>
<td>• Read the Student Resource, <em>Bridge Over the River – Design Brief</em>, along with students, pausing at noted points (refer to Teacher Resource, <em>Bridge Over the River – Design Brief</em>) for suggestions that allow for visualization and discussion.</td>
<td>• Working independently, read each section with the teacher.</td>
</tr>
<tr>
<td></td>
<td>• Visualize the forces on structures under discussion.</td>
</tr>
<tr>
<td>• At noted points, demonstrate key concepts and invite students to participate.</td>
<td>• Jot down key ideas, make sketches and “doodles”.</td>
</tr>
<tr>
<td>• Ask students to take notes and sketch ideas.</td>
<td>• Participate in collaborative/cooperative learning through group discussions as directed by the teacher.</td>
</tr>
<tr>
<td><strong>After</strong></td>
<td></td>
</tr>
<tr>
<td>• Engage students in class and team discussions about the kinds of things that trigger their mental images, and how they visualize forces acting on a structure.</td>
<td>• Discuss how they visualize the forces on structures.</td>
</tr>
<tr>
<td>• Confirm their ideas with the concepts brought out in the text.</td>
<td>• Participate in collaborative/cooperative learning through group discussions as directed by the teacher.</td>
</tr>
<tr>
<td>• Remind students to retain all their notes and sketches, as well as record the steps they took in arriving at solutions to the challenge.</td>
<td>• Organize their notes for future reports and presentations.</td>
</tr>
<tr>
<td>• Remind students that pictures, diagrams and terminology glossaries may help them make more accurate and detailed mental images, and that this will help them arrive at workable solutions to engineering challenges.</td>
<td></td>
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</tbody>
</table>
Bridge Over the River – Design Brief

Overview
Bridges come in all shapes and sizes, and cross everything from small streams on a walking path to some of the largest ocean channels. The shape and size of bridges are determined by many factors, such as the purpose of the bridge, how much weight it needs to carry, what kind of wind forces it will feel, where it is to be situated, and how much money is available to build it. Bridge designers and engineers have to consider all the factors and arrive at the best solution.

As part of the job to design a bridge, engineers will make test models of the bridge to test their ideas. It is much cheaper to make and perhaps break small models than it would be to make and perhaps break a very expensive structure that could cause injury or death.

Mission
Your company, Student Engineers Incorporated, has been asked to design and build a bridge over the [name of local river]. This bridge is to carry cars and trucks across the river at [local spot]. Your manager has asked you to work with a design team that will look at all the options and come up with the best design to fulfill the task. The team with the best design will win the contract to build the real bridge.

Criteria
The bridge will need to carry two lines of traffic across [name of local river] at [local spot]. You will have to consider the local terrain and environmental conditions. The span of the bridge is to be XXXX meters.

The overall design will need to be considered first. You must consider each of the four bridge types:

<table>
<thead>
<tr>
<th>1. Post and beam (includes trusses)</th>
<th>3. Suspension</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Arch</td>
<td>4. Cable Stayed</td>
</tr>
</tbody>
</table>

The overall design must take into account the design best suited to cross the span of the river for the least cost and maximum strength. The design team must decide on the best materials (wood, concrete, steel, etc.).

Procedure
1. Meet with your team and discuss the pros and cons of each type of bridge. Take notes and keep all sketches. When your team has arrived at a conclusion about the best bridge type, discuss it with your manager. You will need your notes and sketches for a presentation to the city later.

2. You will need to build an engineering test model to test the strength of your design. Your manager will give you a kit of modeling materials from which to build a model. He/she will also describe the testing procedure.

3. Your team will need to discuss the best way to build a model with all the available materials. When you have arrived at the best plan, proceed to construct the model and prepare the model for testing.

* Stop to Visualize.
Bridge Over the River – Design Brief

[The following points correspond to the numbers in the accompanying Student Resource, Bridge Over the River - Design Brief. These points indicate where students can use visualization to help them better understand the text.]

1. Ask students to picture bridges they have seen or are familiar with. These may be local, or ones they have seen in the movies or on TV. Ask them to describe the features of the bridge, and what materials the bridge was made of.

2. There have been many bridge disasters, none more famous than the Tacoma Narrows Bridge in Washington State. There are many websites, books and videos of the bridge’s collapse. (Web search “Tacoma Narrows Bridge” and/or “Galloping Gertie”.) Show students pictures (or video) of the collapse. Have students imagine what it would have felt like to be standing on this bridge before it collapsed, or what it would have felt like to be one of the steel cables or the roadway asphalt.

3. You will need pictures of the area in question where the bridge is to be placed. Ask students to imagine themselves flying across the river, or swimming under water. Ask them to describe the terrain, the conditions underwater, and to imagine what a bridge might look like spanning the area.

4. Students may have difficulty visualizing length measurements. Have them discuss their own average height, or the length of a car, then imagine how many of them or how many cars would it take to cross the width of the river. (Actual measurements can be obtained through local maps.)

5. Showing students simple models of the major bridge types will help them understand the concepts of each:
   - Post and beam (and truss): place a shallow notch along the middle, both top and bottom, of a small stick, (or other flexible contrivance). Place the ends of the stick on supports and press down in the middle. Ask students to describe what happens to the notches when the load is applied. This illustrates the concept of compression along the top of a beam (the notch narrows), and tension along the bottom (the notch widens). Ask students to imagine what would happen when you compress or apply tension to common materials, such as wood, concrete, a rope, a straw, rubber bands, paper on edge (both straight and folded accordion-like). Have them discuss buckling under compression, and cracking under tension.
   - Next, have a pair of students face each other with palms touching, and step back from each other without falling over. Ask them where they feel compression and tension. Have one of the students move two steps right or left. (This is torsion, and it is the reason why the Tacoma Narrows Bridge failed under a gusty wind…the gusts raised and lowered the deck until it twisted in the middle.)
   - Arch: Cut a strip of heavy card or cardboard, create an arch along its long dimension. Push on the top of the arch and ask students what they see. (The ends slide away from each other.) Place books to act as abutments with the arched strip between them. Push on the top of the arch. Ask students to observe the results. (The books hold the arch together…the arch is strong in compression.)
Bridge Over the River (continued)

- Suspension: Illustrate suspension cables and anchorages by draping a string or rope over two separated pylons, and have students hold each end. Pull down on the string in the middle and ask the students at each end what they feel. Ask students what they see and describe the concept of tension.

- Cable Stayed: Have a student (or students) hold a rope from each outstretched arm and across the top of their head. Ask them to let their arms fall, and ask them what they sense. (The rope transfers the weight of their arms to the top of their head. The rope is under tension, while their head will experience compression.) Cable stayed bridges are different from suspension in that suspension bridges hold up the bridge between anchorages, while cable stayed bridges hold up the weight from the tower.

6. Ask students to imagine each material under extreme stress...for example, what would fail under compression first: a wood post, a concrete post or a steel pipe? Then, what would fail first if you pulled them under tension? How would they fail? You may need to demonstrate with lightweight examples.

7. Have the students examine the materials and visualize each under compression, tension and torsion as they deliberate about their design ideas. You may want to ask individuals to describe how they think each material would behave. Also ask them to discuss the joining methods, to visualize the types of joinery and the relative strength of each. This will help them understand the requirements for building and testing.
Key Standards for Engaging in Reading: Visualization

This activity is based on the following course expectations, technological literacy benchmarks and employability and innovations skills. These are to guide the teacher in developing assessment strategies and as a tool to illustrate the importance of the activity on developing a student's future career potential.

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SC5 identify forces within a structure that are affected by forces outside the structure (e.g., shear, torsion, tension, and compression within a bridge are affected by external forces such as high wind or ice).

ITEA Technological Literacy Benchmarks

Standard 9: Engineering Design
H. Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

Standard 11: Apply the Design Process
J. Make two-dimensional and three-dimensional representations of the designed solution.
K. Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed.

Conference Board of Canada Employability Skills

Think & Solve Problems
CBC10 assess situations and identify problems
CBC15 readily use science, technology and mathematics as ways to think, gain and share knowledge, solve problems and make decisions
CBC16 evaluate solutions to make recommendations or decisions

Conference Board of Canada Innovation Skills
Creativity and Continuous Improvement Skills
IS3. Seek different points of view - explore options
IS4. Ask questions to assess situations, identify problems, and seek solutions
IS5. Look for surprising connections - be open-minded when exploring possible solutions
Questioning and critiquing ideas within a design challenge is an essential element for arriving at possible solutions. As students read and begin to think about the criteria of a design problem, it is helpful for them to discuss ideas during a team brainstorming challenge. This strategy provides a structure for brainstorming sessions and allows for immediate feedback to students before they commit to solutions. Students exchange their notes and sketches and develop questions and answers in response to each other's ideas.

**Purpose**
- Identify ideas and information that may have been omitted.
- Reconsider and revise initial thinking at an early stage of developing solutions.
- Teach students how to questions themselves and critique ideas.

**Payoff**
Students will:
- conceptualize important design ideas.
- develop skills for analyzing design criteria and critiquing ideas.
- improve focus and attention to detail.

**Tips and Resources**
- This strategy will help students understand written design criteria, and teach them a strategy to work as a team to arrive at the best solution.
- Students ask important questions: the who, what, where, when, why and how (5W+H) in arriving at design solutions. It will also help them predict questions in advance that must be answered before committing to any one design solution.
- Students write down their ideas and pass it on to their fellow students for commentary; teachers should ensure there is plenty of room for annotating, or provide stick-on notes.
- See *Think Literacy: Cross Curricular Approaches, Grades 7-12*, pp. 104-105 for a detailed example of the technique.
- For more information, see:
  - Student Resource, *Design Brief: Bridge Over the River*.
  - Student/Teacher Resource, *Bridge Over the River - Pass It On Instruction Sheet*.
  - Student Resource, *Pass it On Question and Answer Form*.

- To connect these activities to course expectations, technological literacy benchmarks and employability and innovation skills, see Teacher Resource, *Key Standards For Generating Ideas: Adding Content*.

**Further Support**
- Teachers should model the process by walking students through an initial experience, posing questions under each 5W+H.
- For students who are struggling, consider taking them step-by-step through the first steps of the exercise.
### Generating Ideas: Adding Content (Pass It On!)

**Science and Technology Grade 7 (Structures and Mechanisms)**

<table>
<thead>
<tr>
<th>What teachers do</th>
<th>What students do</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before</strong></td>
<td></td>
</tr>
<tr>
<td>• Prepare and distribute handouts and reading materials. (See Student Resources, <em>Design Brief: Bridge Over the River, Bridge Over the River - Pass It On Instruction Sheet, Pass It On Question and Answer Form.</em>) Engage students in a class discussion on the concepts of bridges and ask students to consider bridges they have seen or experienced.</td>
<td>• Students individually analyze the design brief, and note major criteria to consider. (This may also include some group discussions.)</td>
</tr>
<tr>
<td>• Create design groups of 3-5 students.</td>
<td>• Read the instructions with the teacher.</td>
</tr>
<tr>
<td>• Apply questions of who, what, where, when, why and how (5Ws+H) to a design project. Ask students to share questions one might ask related to this project.</td>
<td></td>
</tr>
<tr>
<td>• Remind students that the purpose is to ask important questions to help the group arrive at the best design.</td>
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</tr>
<tr>
<td><strong>During</strong></td>
<td></td>
</tr>
<tr>
<td>• Ask students to write a single paragraph containing a description of a possible solution (type of bridge that will be the best design for the circumstances based on the criteria provided).</td>
<td>• Individually, write a single paragraph description of a possible solution.</td>
</tr>
<tr>
<td>• Time the students - have them pass their work to the person to the left and add questions to the work that is handed to them. In 3 to 5 minutes, depending on length of the work, call “time” and have the students pass their work to the left again.</td>
<td>• Working within their groups, pass their paragraphs to the left, read the passage quietly.</td>
</tr>
<tr>
<td>• Have students continue until the work has been returned to the original author.</td>
<td>• As they read, jot down questions on the paper (or post-it-notes) based on the 5Ws+H.</td>
</tr>
<tr>
<td><strong>After</strong></td>
<td></td>
</tr>
<tr>
<td>• Ask the students to use the questions and answers on their original paper to develop a rational for their design decisions.</td>
<td>• Use their notes, questions and answers for future reports and presentations.</td>
</tr>
<tr>
<td>• Ask each group to discuss and assist each other to answer the questions, and formulate a decision on a design.</td>
<td></td>
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</tbody>
</table>
Design Brief: Bridge Over the River

Overview
Bridges come in all shapes and sizes, and cross everything from small streams on a walking path to some of the largest ocean channels. The shapes and sizes of bridges are determined by many factors, such as the purpose of the bridge, how much weight it needs to carry, what kind of wind forces it will feel, where it is to be situated, and how much money is available to build it. Bridge designers and engineers have to consider all the factors and arrive at the best solution.

As part of the job to design a bridge, engineers will make test models of the bridge to test their ideas. It is much cheaper to make and perhaps break small models than it would be to make and perhaps break a very expensive structure that could cause injury or death.

Mission
Your company, Student Engineers Incorporated, has been asked to design and build a bridge over the [name of local river]. This bridge is to carry cars and trucks across the river at [local spot]. Your boss has asked you to work with a design team that will look at all the options and come up with the best design to fulfill the task. The team with the best design will win the contract to build the real bridge.

Criteria
The bridge will need to carry two lines of traffic across [name of local river] at [local spot]. You will have to consider the local terrain and environmental conditions. The span of the bridge is to be XXXX meters.

The overall design will need to be considered first. You must consider each of the four bridge types:

<table>
<thead>
<tr>
<th>1. Post and beam (includes trusses)</th>
<th>3. Suspension</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Arch</td>
<td>4. Cable Stayed</td>
</tr>
</tbody>
</table>

The overall design must take into account the design best suited to cross the span of the river for the least cost and maximum strength. You must decide on the best materials (wood, concrete, steel, etc.).

Procedure
1. Meet with your team and discuss the pros and cons of each type of bridge. Take notes and keep all sketches. When your team has arrived at a conclusion about the best bridge type, discuss it with your boss. You will need your notes and sketches for a presentation to the city later.

2. You will need to build an engineering test model to test the strength of your design. Your boss will give you a kit of modeling materials from which to build a model. He/she will also describe the testing procedure.

3. Your team will need to discuss the best way to build a model with all the available materials. When you have arrived at the best plan, proceed to construct the model and prepare the model for testing.
Bridge Over the River - Pass It On Instruction Sheet

You may have heard...many minds are better than one! When designing structures as complex as bridges, it takes many people with different talents to come up with the best solutions. In this assignment, you and your team will play a game of questions...by working together asking and answering questions, you should come up with the best ideas for your design challenge. Good luck!

Instructions
After reading Design Brief: Bridge Over the River, carefully note the criteria that the design has to satisfy. Make quick notes, sketches, doodles - whatever it takes to help you think.

When you have an idea (or several ideas) for a design to solve the challenge, write a paragraph stating your thoughts and why it would be a good idea. Use the Pass It On Question and Answer form.

Your teacher will instruct you to pass your paper on to your teammate on the left. When you receive your teammate’s paper, read over their idea quickly. Think of some questions that you want your teammate to explain. Your questions should be based on the 5Ws +H: what, where, when, why, who and how.

Sample questions may be:
- What is the main idea here?
- Where will the point of failure be located?
- When will it fail (under what kind of load)?
- Why did you decide to make it like that?
- Who will build what part?
- How will you assemble a model?

Work quietly, and follow instructions from your teacher. If you can’t read or understand something, don’t ask the writer, just write down a comment such as “I don’t get this”, or “I can’t read this”.

Once you have a chance to read a couple of your teammate’s papers, then you will be asked to try to answer some of the questions. Once you get your own paper back, you will need to write all the questions and answers, and attempt to answer any questions in a proposal. You may work with your teammates at this point.

Do your best, and remember, all this is to help you get the best solution. Engineers need to discuss and challenge each other to make sure they have considered all ideas, and to get at the best solutions.
Pass It On Question and Answer Form

My ideas are:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

<table>
<thead>
<tr>
<th>Our Questions Are:</th>
<th>Some Answers Are:</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>
Key Standards for Generating Ideas: Adding Content

This activity is based on the following course expectations, technological literacy benchmarks and employability and innovations skills. These are to guide the teacher in developing assessment strategies and as a tool to illustrate the importance of the activity on developing a student’s future career potential.

References
The Ontario Curriculum, Grades 1-8 Science and Technology (1998)
International Technology Education Association (ITEA) Standards for Technological Literacy, Content for the Study of Technology (2000)
Conference Board of Canada Innovation Skills Profile (2002)

Course Expectations
Structures and Mechanisms: Grade 7 - Structural Strength and Stability

Overall Expectations
By the end of Grade 7, students will:
SOV3 demonstrate an understanding of the factors (e.g., availability of resources) that must be considered in the designing and making of products that meet a specific need;

Specific Expectations
SD2 formulate questions about and identify needs and problems related to the strength of structures, and explore possible answers and solutions (e.g., determine what caused structural failure and propose ways of supporting a specific load);
SR4 recognize that a solution to a problem may result in creating new problems in other areas, and that a solution to a problem may be found while one is working on solving a problem in another area.

ITEA Technological Literacy Benchmarks

Standard 8: The Attributes of Design
E. Design is a creative planning process that leads to useful products and systems.

Standard 9: Engineering Design
G. Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.

Conference Board of Canada Employability Skills

Communicate
CBC2 write and speak so others pay attention and understand
CBC3 listen and ask questions to understand and appreciate the points of view of others

Think and Solve Problems
CBC14 be creative and innovative in exploring possible solutions
CBC16 evaluate solutions to make recommendations or decisions

Work With Others
CBC43 be flexible: respect, be open to and supportive of the thoughts, opinions and contributions of others in a group
CBC45 accept and provide feedback in a constructive and considerate manner

Conference Board of Canada Innovation Skills

Creativity And Continuous Improvement Skills
IS6. Seek different points of view — explore options
IS7. Be adaptable and flexible when challenging ideas
IS8. Ask questions to assess situations, identify problems, and seek solutions
IS10. Demonstrate trust in other people's ideas and actions
IS14 Be open to new ideas and different ways of doing things—commit to continuous improvement
Small-group Discussions: Discussion Web
Science and Technology Grade 7 (Structures and Mechanisms)

The Discussion Web is a technique to encourage the sharing of ideas and to develop critical thinking, both individually and in a group. In the field of technological innovation, the analysis of the benefits and disadvantages associated with any particular strategy or solution is important. Often, a series of compromises must be made to arrive at the optimal solution. Students in design and technology determine the benefits and disadvantages associated with their ideas, and develop ways to rationalize their solutions. They learn to work with others, and to appreciate opposing ideas. Team discussions are usually the “spark” that generates design ideas, and this strategy provides a structured way to encourage those discussions. In this strategy, students begin sharing their ideas in pairs, then build to a larger group. The discussion web provides practice in speaking, reading, and writing.

Purpose
- Give students the opportunity to develop their ideas about opposing views of technology and share them with classmates in a situation that requires critical thinking.

Payoff
Students will:
- be involved in discussion, team work and critical thinking.
- take responsibility for developing and sharing their ideas.
- reflect on their own developing discussion skills.

Tips and Resources
- This strategy gives students time to think about the important issue of the benefits and disadvantages of technology (Is technology our friend or our foe?). It provides a method to examine an issue and gather evidence for both sides of a debate. There are usually very well defined positions “for” and “against” technology in almost any application, and the Discussion Web will help students understand the techniques of design, rationalization and critical thinking. While in this particular case students are asked to examine the larger social issue of the use of technologies, this technique can be applied to any design challenge.
- The accompanying Teacher Resource, Discussion Web T-Chart: Is Technology a Friend or Foe? can be used to structure the students’ arguments. It can be modified for any type of design challenge process.
- See the reading selection, Student Resource, Technology: Friend or Foe?
- To connect course expectations, technological literacy benchmarks and employability and innovation skills, see Teacher Resource, Key Standards For Small-group Discussions: Discussion Web.

Further Support
- Some students may need support with note taking while they read, or clarification about arguments that support each side of the issue.
- Students may need encouragement to argue their ideas, or to question ideas. Teachers may wish to model the initial arguments, and to show examples of recent political debates to encourage their understanding of the process.
- Students can fill out the Discussion Web T-chart together in pairs as the initial step.
# Small-group Discussions: Discussion Web

**Science and Technology Grade 7 (Structures and Mechanisms)**

<table>
<thead>
<tr>
<th>What teachers do</th>
<th>What students do</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before</strong></td>
<td></td>
</tr>
<tr>
<td>• Gather a few pictures of technology in action such as a space shuttle, an assembly line robot, or a concept car. Help prepare the students’ focus before assigning the reading.</td>
<td></td>
</tr>
<tr>
<td>• Using <em>Technology: Friend or Foe?</em>, focus on the question, “Is technology our friend or foe?”</td>
<td></td>
</tr>
<tr>
<td><strong>During</strong></td>
<td></td>
</tr>
<tr>
<td>• Explain to students that they will have to develop support for both viewpoints by citing specific reasons.</td>
<td>• Think about and individually record ideas on both sides of the issue, before using the blank T-chart.</td>
</tr>
<tr>
<td>• Allow enough time for students to think and write down reasons for each viewpoint.</td>
<td>• Share ideas with a partner, adding any new ideas to their T-chart.</td>
</tr>
<tr>
<td>• Put students in pairs to share their written ideas.</td>
<td>• Move on to sharing ideas in a group of four, adding any additional points to the T-chart; the larger group must then decide which side of the issue to support, based on both the quantity and quality of the arguments on each side.</td>
</tr>
<tr>
<td>• Combine two pairs of students and have them compare their ideas and form a conclusion on which viewpoint to support.</td>
<td>• Reach a conclusion as an entire class about the viability of each position.</td>
</tr>
<tr>
<td>• Call on a representative from each group to share the group’s conclusion with the class.</td>
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<tr>
<td><strong>After</strong></td>
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</tr>
<tr>
<td>• Follow up by asking students to individually write a paragraph about their own position on the question, “Is technology our friend or our foe?” and the reasons for taking it.</td>
<td>• Write about their position and reasons for it.</td>
</tr>
<tr>
<td>• Provide time and a framework for students to reflect on the discussion skills they used during the activity, their strengths and how they can improve.</td>
<td>• Reflect on the discussion skills they used and how they can improve participation and effectiveness in small-group discussions.</td>
</tr>
</tbody>
</table>


Discussion Web T-Chart: Is Technology a Friend or Foe?

<table>
<thead>
<tr>
<th></th>
<th>Friend</th>
<th></th>
<th>Foe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve lives</td>
<td></td>
<td>Ruins Lives</td>
<td></td>
</tr>
<tr>
<td>Saves money and resources</td>
<td></td>
<td>Costs money and resources</td>
<td></td>
</tr>
<tr>
<td>Improves the environment</td>
<td></td>
<td>Ruins the environment</td>
<td></td>
</tr>
<tr>
<td>Makes everything better, faster, cheaper, stronger</td>
<td></td>
<td>Causes destruction</td>
<td></td>
</tr>
</tbody>
</table>
Technology: Friend or Foe?

Michael Hacker and Robert Barden are the authors of the book, *Living with Technology*. Together they have written about the need for people to understand all aspects of technology today. Their writing makes the reader stop and think. After reading the rest of this article you will be asked an important question. Your answer could prove to be very important to your future. Continue reading to discover the question.

In early times when the early pioneers were settling Canada, it took months for people to travel across the country. Horse and buggy was a slow and uncomfortable means of travel. News, which took weeks or months to arrive at the general store, was often out of date before reaching its destination. Most products found in pioneer homes were made by hand, by pioneers themselves. Today things are quite different.

Airplanes take us from coast to coast in a few hours, the Internet and television informs us of news as it is happening and most everything we need for our homes is produced through manufacturing technology. Technology has made many improvements to our standard of living.

There is another side to technology; however, that we sometimes fail to see. For example, each year, vehicles designed to save time, claim hundreds and thousands of victims as large trucks share highways with passenger buses and family cars. In 1986 seven astronauts were killed when the Space Shuttle Challenger blew up only minutes after it left the launch pad, then Columbia disintegrated in the sky as it was landing in 2002. Low-level radiation leaks from modern conveniences, such as, microwaves and cell phones are believed to be putting many people at risk for cancer.

Some people feel that technology is developing too quickly. Other people say technology leads to too many disasters. Air pollution, noise pollution, crowded highways, and diseases like cancer can be blamed on technology.

Is technology our friend or our foe? Is it good or is it evil? Would you really want to live like the pioneers for the rest of your life? Is it possible to slow down the progress of technology? What changes will you see in your future because of technology? These are all important questions to think about when we ask ourselves the question, “Is technology our friend or our foe?” What do you think?
Key Standards for Small Group Discussion: Discussion Web

This activity is based on the following course expectations, technological literacy benchmarks and employability and innovations skills. These are to guide the teacher in developing assessment strategies and as a tool to illustrate the importance of the activity on developing a student’s future career potential.

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SD2 formulate questions about and identify needs and problems related to the strength of structures, and explore possible answers and solutions (e.g., determine what caused structural failure and propose ways of supporting a specific load).

ITEA Technological Literacy Benchmarks
Standard 4: The cultural, social, economic, and political effects of technology
E Technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences.
F The development and use of technology poses ethical issues.

Conference Board of Canada Employability Skills
Communicate
CBC3 listen and ask questions to understand and appreciate the points of view of others

Think & Solve Problems
CBC12 recognize the human, interpersonal, technical, scientific and mathematical dimensions of a problem

Work with Others
CBC41 understand and work within the dynamics of a group
CBC43 be flexible: respect, be open to and supportive of the thoughts, opinions and contributions of others in a group

Conference Board of Canada Innovation Skills
Creativity and Continuous Improvement Skills
IS9. Seek different points of view - explore options
IS10. Be adaptable and flexible when challenging ideas
IS11. Ask questions to assess situations, identify problems, and seek solutions
Technology students constantly use graphical style text in the form of instruction manuals and textbooks related to engineering processes, design challenges and technical operations. Graphical text forms (such as diagrams, photographs, drawings, sketches, graphs, schedules, maps, charts, tables and timelines) are intended to communicate information in a concise format and illustrate how one piece of information is related to another. Understanding how to analyze information in graphical text format helps the student become an effective reader.

Purpose
- Become familiar with the elements and features of graphical texts for information and meaning.
- Increase student confidence in their abilities to read and understand technological material.
- Develop skills in analyzing technical information.
- Explore a process for reading graphical texts that can be transferred to other instruction manuals used in technology.

Payoff
Students will:
- develop skills for independent reading.
- become efficient at “mining” manuals and texts for meaning when completing technical tasks.
- improve conceptualization of design ideas.

Tips and Resources:
- It is suggested that teachers have visual aids (e.g., digital photographs, illustrations, partially-built robots at varying stages of completion) in order to support the graphical text.
- Understanding step-by-step instructions is made easier by the use of photos, drawings and sketches. Some of the graphical features that are typically found in technical instruction manuals include:
  - print features (such as typeface, size of type, bullets, titles, headings, subheadings, italics, labels and captions). Some manuals also contain instructions in different languages that can support ESL students.
  - organizational features (such as table of contents, legends, informational insets or keys, labels and captions).
  - design features (such as colour, shape, line, placement and balance). Most technical manuals also include images that add meaning and instruction.
  - organizational patterns (such as sequential, categorical, and explanatory).
- By taking the time to consciously analyze charts, graphs, illustrations and other graphical forms of text, students gain a deeper understanding of increasingly complex technical material. Teachers should point out that learning to analyze graphical text is an important step in becoming effective readers of technical materials.
- For more information, see:
  - Student Resource, Robot Design.
  - Student Resource, Designing Robots: Key Components.
- To connect this activity to course expectations, technological literacy benchmarks and employability and innovation skills see Teacher Resource, Key Standards for Engaging in Reading Different Text Forms: Reading Graphical Texts.

Think Literacy: Cross Curricular Approaches, Grades 7-12, pp. 84-86.
Instructional manuals that come with robotics kits

Further Support
- Provide students with specific tasks to describe the meaning of graphical materials. This will help students overcome problems in comprehension of complex instructions in robotics design and programming.
## Engaging in Reading Different Text Forms: Reading Graphical Texts

### Science and Technology Grade 8 (Structures and Mechanisms)

<table>
<thead>
<tr>
<th>What teachers do</th>
<th>What students do</th>
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<tbody>
<tr>
<td><strong>Before</strong></td>
<td></td>
</tr>
<tr>
<td>• Review Teacher Resource, <em>Robot Design: Incorporating Graphical Text</em> for the process.</td>
<td>• Listen actively and critically to understand and learn.</td>
</tr>
<tr>
<td>• Prepare sufficient numbers of Student Resource, <em>Designing Robots: Key Components</em>.</td>
<td>• Participate in class discussions, consider the different types of robots you have seen in movies, games, etc.</td>
</tr>
<tr>
<td>• Engage students in a class discussion on the concept of mimicking living systems in robotics and ask students to consider robots they have seen or experienced in movies, at home and in animation/cartoons.</td>
<td>• Take notes and quick sketches regarding key robot concepts discussed.</td>
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<tr>
<td>• Discuss vocabulary, control logic, and robotic components and systems.</td>
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<tr>
<td><strong>During</strong></td>
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<tr>
<td>• Read over the instructions in the Student Resource, <em>Robot Design</em>, with the class. (See Teacher Resource, <em>Robot Design: Incorporating Graphical Text</em>.)</td>
<td>• Read each section along with the teacher.</td>
</tr>
<tr>
<td>• At noted points, demonstrate key concepts and invite students to participate. Respond to any questions that arise from the instructions.</td>
<td>• Jot down key ideas, make notes and sketches of important ideas.</td>
</tr>
<tr>
<td>• Assign students in small teams of 3-4.</td>
<td>• Participate in group discussions as directed by the teacher.</td>
</tr>
<tr>
<td>• Ask students to take notes where applicable.</td>
<td>• Identify as many of the key robotic components in the picture of the Mars rover as possible.</td>
</tr>
<tr>
<td>• Decode the chart and image provided in the graphical text sample by taking the class through a step-by-step analysis of the chart.</td>
<td>• Ask for clarification of the labels on the diagram as needed.</td>
</tr>
<tr>
<td>• Ask students to correlate the chart information with the image of the Mars rover.</td>
<td></td>
</tr>
<tr>
<td><strong>After</strong></td>
<td></td>
</tr>
<tr>
<td>• Discuss the robotic systems described in the text as they apply to the Student Resource, <em>Robot Design</em>.</td>
<td>• Organize and review notes of important points for future reports and presentations.</td>
</tr>
<tr>
<td>• Remind students to retain all their notes and sketches, as well as record the steps they have taken and will take in arriving at solutions to the design challenge.</td>
<td>• Participate in group discussions as directed by the teacher.</td>
</tr>
<tr>
<td>• Discuss next steps with the students using the component parts discussed to solve the design challenges of their robot.</td>
<td>• Review <em>Designing Robots: Key Components</em> throughout the design phase of team’s robot.</td>
</tr>
</tbody>
</table>
## Designing Robots: Key Components

<table>
<thead>
<tr>
<th>Action</th>
<th>Human</th>
<th>Robot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thinking, info processing</td>
<td>Brain, nerves</td>
<td>Microprocessor, wires</td>
</tr>
<tr>
<td>Move</td>
<td>Legs</td>
<td>Wheels, legs</td>
</tr>
<tr>
<td>Power Generation</td>
<td>Eating, breathing</td>
<td>Solar panels, batteries</td>
</tr>
<tr>
<td>Power Storage</td>
<td>Fat, muscle tissue</td>
<td>Batteries</td>
</tr>
<tr>
<td>Power Transmission</td>
<td>Blood vessels</td>
<td>Electrical Wires</td>
</tr>
<tr>
<td>See</td>
<td>Eye</td>
<td>Camera</td>
</tr>
<tr>
<td>Hear</td>
<td>Ears</td>
<td>Microphone</td>
</tr>
<tr>
<td>Taste</td>
<td>Tongue</td>
<td>Chemical sensors</td>
</tr>
<tr>
<td>Feel</td>
<td>Skin nerves</td>
<td>Gripper sensors</td>
</tr>
<tr>
<td>Smell</td>
<td>Nose</td>
<td>Chemical sensors</td>
</tr>
<tr>
<td>Hold, carry, handle</td>
<td>Hands</td>
<td>Grippers</td>
</tr>
<tr>
<td>Communicate</td>
<td>Speak, hand signals, write</td>
<td>Radio Antennas</td>
</tr>
</tbody>
</table>

Below is a picture of the design of the Mars Rovers Spirit and Opportunity. See if you can pick out the components of a robot listed in the table above.

Image courtesy NASA
Chart courtesy millenniumWAVE technologies 2004
Teacher Resource

Robot Design: Incorporating Graphical Text

Description
Students are to work in groups and assume the role of engineers at Robots Inc. who will do research, design and build a robotic rover. The team will start by considering the key robotic components as illustrated in the Student Resource, Designing Robots: Key Components. This particular exercise is to provide an opportunity to teach students strategies to use when reading and analyzing graphical text as found in instructional manuals or illustrated texts. Teachers should check to ensure students comprehend graphical text throughout the project.

The Process
The initial phase of the design process is to consider the chart of human-robotic functions. (This particular exercise is to provide students with an understanding of reading comprehension through visual text and illustrations.) Each engineering team then considers the design brief (see Student Resource, Robot Design) and brainstorms possible design ideas. Each team incorporates the concepts developed here and should be ready to explain their understanding in formative evaluations and presentations. Design solutions should be evaluated on how well they have satisfied the design criteria and incorporated (pre-determined) concepts. As students work through the graphical text elements and instructional materials they become more adept at comprehending technical materials and become more skilful in designing solutions to technological challenges.

Planning Notes
The activities require that the teacher prepare materials before classes begin. Teachers need to become familiar with various design and programming concepts for robotics, as well as methods that will be used in the assembly of this project. Samples of graphical text from instruction manuals, textbooks, etc. should be prepared beforehand. Teachers should consider requiring students to demonstrate that they can comprehend information in charts, tables, illustrations and other graphical forms.

Teaching/Learning Strategies
- The provided graphical text connects human functions with robotic components. Through analyzing these connections, the variety of common robotic systems can be appreciated and can help students in the design of any robot system.
- To introduce the assignment, teachers should first make parallels with human and robot functions e.g., the five senses. Teachers can ask students to describe what they know about the robots they have experienced. (movies, books, games, etc.)
- Distribute the Student Resource, Designing Robots: Key Components, and initiate discussion on each of the components described in the chart. Teachers point out the row/column features of the chart at the beginning of the discussions.
- Teachers can either ask the class as a whole, in separate groups or individually to connect the components from the chart to the accompanying illustration. (Note that not all elements are apparent or included (e.g., the MARS rover did not have hearing included in their design. However, teachers can ask students to describe how they might incorporate said functions).
- During the project, teachers should ask students to read and analyze other graphical texts as they are encountered.
Robot Design

*Please keep all sheets in your Technology Binder.*

**The Design Challenge**
Robot Inc. has just received the contract to design and build a robotic rover for searching for metal in the local landfill. You and your team of robotics engineers need to first consider the key elements of robotic functions in the design of your solution.

**Procedure**
- **Step 1** Analyze how robots mimic human functions, such as the five senses, movements, generate and store power, etc.
- **Step 2** Show how the Mars rovers perform the functions you have just listed.
- **Step 3** Consider the design challenge your clients have provided you, and list the things you have to consider for a successful design.
- **Step 4** With your team, complete several sketches of your ideas. Consider the materials that are available.
- **Step 5** Present your ideas to the client for approval. Don’t forget to describe how your robot will perform all the necessary functions.
- **Step 6** When your client approves, you can begin to construct your robot and test its functions. Don’t forget to keep all your notes and sketches for later reports and the project presentations.

**Remember!**
*Keep working with your first idea....don’t get stuck on only one idea...modify it....change it...make it better...add something...take something away....look at it upside down....get creative!*
Teacher Resource

Key Standards for Engaging in Reading Different Text Forms: Reading Graphical Texts

This activity is based on the following course expectations, technological literacy benchmarks and employability and innovations skills. These are to guide the teacher in developing assessment strategies and as a tool to illustrate the importance of the activity on developing a student's future career potential.

References
The Ontario Curriculum, Grades 1-8 Science and Technology (1998)
International Technology Education Association (ITEA) Standards for Technological Literacy, Content for the Study of Technology (2000)
Conference Board of Canada Innovation Skills Profile (2002)

Course Expectations
Structures and Mechanisms: Grade 8 - Mechanical Efficiency
Overall Expectations
By the end of Grade 8, students will:
MOV1 demonstrate an understanding of the factors that contribute to the efficient operation of mechanisms and systems;

Specific Expectations
MC5 explain, using their observations, how the use of appropriate levers and ways of linking the components of fluid systems can improve performance of the systems (e.g., systems in a steam shovel, in a robot);
MC9 predict the mechanical efficiency of using different mechanical systems (e.g., a winch).

ITEA Technological Literacy Benchmarks
Standard 2 The Core Concepts in Technology
M: Technological systems include input, processes, output, and at times feedback.

Standard 3: The relationships among technologies and connections between technology and other fields
D: Technological systems often interact with each other.

Conference Board of Canada Employability Skills
Think & Solve Problems
CBC10 assess situations and identify problems
CBC15 readily use science, technology and mathematics as ways to think, gain and share knowledge, solve problems and make decisions
CBC16 evaluate solutions to make recommendations or decisions
CBC17 implement solutions

Work Safely
CBC40 be aware of personal and group health and safety practices and procedures, and act in accordance with these

Conference Board of Canada Innovation Skills
Act and Contribute
IS1 Seek different points of view - explore options
IS21 Learn from your experiences - do not be afraid to make mistakes
Technological processes often require students to prioritize information and put data into a logical, sequential, step-by-step format. Templates are used to assist in organizing the steps of the project. A template or framework is a skeletal structure for a writing form that allows students to organize their thoughts and researched information in order to create a document. A flow chart is a good example of this style of writing that can assist in prioritizing, sequencing and organizing data to achieve a pre-determined end. This type of writing allows for ease of understanding and guided learning when completing complex multi-step activities, such as designing and programming a robot. Many essential engineering principles are involved in this type of activity and thus require a logical format.

**Purpose**
- Provide students with a template to scaffold their understanding (of a form of writing) and help organize information while working on a design challenge.
- Develop students’ understanding of control logic and the on-going decisions that need to be made at pivotal points in the design of a robot.

**Payoff**
Students will:
- learn the common elements of a flow chart template and be able to assemble a logical sequence using appropriate symbols with proper placement.
- develop critical thinking skills as they relate to making logical decisions that help solve a design challenge.
- learn the common and transferable skill of recognizing standard flow chart symbols.
- use sequential logic to assist in decision making.

**Tips and Resources**
- To help students understand how to construct a flow chart, they may first need to deconstruct an example of a typical robotic task. A sample flow chart template and key for directing a robot to find a pop can in an enclosed course is included. By deconstructing the example, students can analyze how this writing form is used in robotic programming.
- For more information, see:
  - Student/Teacher Resource, *Sample “Find the Can” Flow Chart.*
  - Student Resource, *“Find the Can” Flow Chart Template.*
  - Student Resource, *“Find the Can” Flow Chart.*
- To connect course expectations to technological literacy benchmarks, employability and innovation skills see Teacher Resource, *Key Standards for Writing for a Purpose Using Templates.*

**Further Support**
- The template for any individual writing assignment can be revised to make the accommodations necessary for students with special needs. For example, reduce the amount or complexity of information required to place on the flow chart or create differing levels of complexity for research. Teachers may also provide direct assistance throughout the entire task.
- Robot kits and robot websites give further examples of tasks and associated programming examples. It may help to show students various robot tasks (e.g., Mars rovers) at the outset of this assignment.
## Writing for a Purpose: Using Templates

### Science and Technology Grade 8 (Structures and Mechanisms)

<table>
<thead>
<tr>
<th>What teachers do</th>
<th>What students do</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before</strong></td>
<td></td>
</tr>
<tr>
<td>• Prepare the Student/Teacher Resources, <em>Standard Flow Chart Shapes</em>, and Sample “Find the Can” Flow Chart, as well as Student Resources, “Find the Can” Flow Chart Template and Find the Can Flow Chart. It may help to have an overhead transparency or computer projection of the templates so that all students can follow the instructions.</td>
<td>• Review the <em>Standard Flow Chart Shapes</em>.</td>
</tr>
<tr>
<td>• Model the method of deconstructing the commands in the sample flow chart using the symbols identified on <em>Standard Flow Chart Shapes</em>. Prompt students to ask whether certain elements are an action, a decision or an output. Ask what shape/symbol would represent that data on a typical flow chart, and where to place this information logically and sequentially.</td>
<td>• Using the template answer the questions and draw the appropriate symbols and labels as required.</td>
</tr>
<tr>
<td>• Model how to answer questions and draw symbols and labels in the flow chart so that a robot can be programmed to find the can. Use Student/Teacher Resource, Sample “Find the Can” Flow Chart and Student Resource, “Find the Can” Flow Chart.</td>
<td>• Read the example and follow along with the teacher’s instructions on decoding the flow chart’s sequence and logic.</td>
</tr>
<tr>
<td>• Complete “Start” and Decision 1 with the class.</td>
<td>• Work in groups to complete the blank flow chart template provided.</td>
</tr>
<tr>
<td>• Ask the students to work in teams of three or four to deconstruct the rest of the example.</td>
<td></td>
</tr>
<tr>
<td><strong>During</strong></td>
<td></td>
</tr>
<tr>
<td>• Direct students to use templates provided to organize the information and develop the logical sequence.</td>
<td>• Work in groups to determine what happens in each subsequent section of the flow chart. Decide what comes first, where to place the next task, what decisions need to be made and where the flow of operations leads.</td>
</tr>
<tr>
<td>• Monitor student’s work as they complete the template.</td>
<td>• Individually, complete a flow chart by transferring the appropriate steps from the template information.</td>
</tr>
<tr>
<td><strong>After</strong></td>
<td></td>
</tr>
<tr>
<td>• Use peer, self and/or teacher assessment of the completed templates and flow charts.</td>
<td>• Participate in peer or self assessment of the completed flow charts in a subsequent class.</td>
</tr>
<tr>
<td>• Discuss the sample flow chart and describe how similar methods can generate complex robotic actions.</td>
<td>• Share in whole class discussion following the group work on transferable skills and technologies.</td>
</tr>
</tbody>
</table>
# Standard Flow Chart Shapes

Flowcharts use special shapes to represent different types of actions or decisions. Lines and arrows show the sequence of the steps, and the relationships among them.

<table>
<thead>
<tr>
<th>Shape</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Start/End" /></td>
<td>The terminator symbol marks the starting or ending point of the system. It usually contains the word &quot;Start&quot; or &quot;End&quot; or could contain Start/End if the end point is a return to start.</td>
</tr>
<tr>
<td><img src="image" alt="Action or Process" /></td>
<td>A box can represent a single step (&quot;add two cups of flour&quot;) or an entire sub-process (&quot;make bread&quot;) within a larger process.</td>
</tr>
<tr>
<td><img src="image" alt="Decision" /></td>
<td>A decision or branching point. Lines representing different decisions emerge from different points of the diamond. A typical decision may involve a YES/NO answer, resulting in two different results.</td>
</tr>
<tr>
<td><img src="image" alt="Input/Output" /></td>
<td>Represents material or information entering or leaving the system, such as customer order (input) or a product (output).</td>
</tr>
<tr>
<td><img src="image" alt="Connector" /></td>
<td>Indicates that the flow continues on another page, where a matching symbol (containing the same letter) has been placed.</td>
</tr>
<tr>
<td><img src="image" alt="Flow" /></td>
<td>Lines indicate the sequence of steps and the direction of flow.</td>
</tr>
</tbody>
</table>
THINK LITERACY: Subject-Specific Examples Technology, Grades 7-9

Student/Teacher Resource

Sample “Find the Can” Flow Chart

The terminator symbol marks the starting or ending point of the system. It usually contains the word “Start” or “End.”

A box can represent a single step (“add two cups of flour”), or an entire subprocess (“make bread”) within a larger process.

A printed document or report.

A decision or branching point. Lines representing different decisions emerge from different points of the diamond.

Represents material or information entering or leaving the system, such as customer order (input) or a product (output).

Indicates that the flow continues on another page, where a matching symbol (containing the same letter) has been placed.

Lines indicate the sequence of steps and the direction of flow.
“Find the Can” Flow Chart Template

Using this template, and the Sample “Find the Can” Flow Chart, answer the questions for each step and draw the symbol and labels that need to be placed in the flow chart so that the robot can be programmed to find the can.

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Symbol and Labels</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Start</strong></td>
<td>What symbol do you use to start, and where do you place it?</td>
</tr>
<tr>
<td><strong>Decision 1</strong></td>
<td>What does your robot need to do? What decision does it have to make? What symbol and text labels do you use?</td>
</tr>
<tr>
<td><strong>Decision Branch YES</strong></td>
<td>What does your robot need to do if the first decision is YES? What is the next step? What symbol and text labels do you use for this step?</td>
</tr>
<tr>
<td><strong>Decision Branch NO</strong></td>
<td>What does your robot need to do if the first decision is NO? What is the next step? What symbol and text labels do you use?</td>
</tr>
<tr>
<td><strong>Decision 2</strong></td>
<td>What does your robot need to do? What decision does it have to make? What symbol and text labels do you use?</td>
</tr>
<tr>
<td><strong>Decision Branch YES</strong></td>
<td>What does your robot need to do if the first decision is YES? What is the next step? What symbol and text labels do you use for this step?</td>
</tr>
<tr>
<td><strong>Decision Branch NO</strong></td>
<td>What does your robot need to do if the first decision is NO? What is the next step? What symbol and text labels do you use?</td>
</tr>
</tbody>
</table>
“Find the Can” Flow Chart Template continued…

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Symbol and Labels</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Decision 3</strong>&lt;br&gt;What does your robot need to do?&lt;br&gt;What decision does it have to make?&lt;br&gt;What symbol and text labels do you use?&lt;br&gt;&lt;br&gt;<strong>Decision Branch YES</strong>&lt;br&gt;What does your robot need to do if the first decision is YES?&lt;br&gt;What is the next step?&lt;br&gt;What symbol and text labels do you use for this step?&lt;br&gt;&lt;br&gt;<strong>Decision Branch NO</strong>&lt;br&gt;What does your robot need to do if the first decision is NO?&lt;br&gt;What is the next step?&lt;br&gt;What symbol and text labels do you use?&lt;br&gt;&lt;br&gt;<strong>Decision 4</strong>&lt;br&gt;What does your robot need to do?&lt;br&gt;What decision does it have to make?&lt;br&gt;What symbol and text labels do you use?&lt;br&gt;&lt;br&gt;<strong>Decision Branch YES</strong>&lt;br&gt;What does your robot need to do if the first decision is YES?&lt;br&gt;What is the next step?&lt;br&gt;What symbol and text labels do you use for this step?&lt;br&gt;&lt;br&gt;<strong>Decision Branch NO</strong>&lt;br&gt;What does your robot need to do if the first decision is NO?&lt;br&gt;What is the next step?&lt;br&gt;What symbol and text labels do you use?&lt;br&gt;&lt;br&gt;<strong>END</strong>&lt;br&gt;What does the robot need to do when it completes the task?&lt;br&gt;What symbol and text labels do you use?</td>
<td></td>
</tr>
</tbody>
</table>
“Find The Can” Flow Chart

Name: _______________________

Date: _______________________

Class: _______________________

Draw your flow chart here
THINK LITERACY: Subject-Specific Examples Technology, Grades 7-9

Teacher Resource

Key Standards for Writing for a Purpose: Using Template

This activity is based on the following course expectations, technological literacy benchmarks and employability and innovations skills. These are to guide the teacher in developing assessment strategies and as a tool to illustrate the importance of the activity on developing a student’s future career potential.

References
The Ontario Curriculum, Grades 1-8 Science and Technology (1998)
International Technology Education Association (ITEA) Standards for Technological Literacy, Content for the Study of Technology (2000)
Conference Board of Canada Innovation Skills Profile (2002)

Course Expectations
Structures and Mechanisms: Grade 8 - Structural Mechanical Efficiency

Overall Expectations
By the end of Grade 8, students will:

MOV1 demonstrate an understanding of the factors that contribute to the efficient operation of mechanisms and systems

Specific Expectations
MD1 formulate questions about and identify needs and problems related to the efficient operation of mechanical systems, and explore possible answers and solutions (e.g., test a device at each stage of its development and evaluate its performance in relation to specific criteria);

MD5 communicate the procedures and results of investigations for specific purposes and to specific audiences, using media works, written notes, descriptions charts, graphs, drawings, and oral presentations (e.g., make a display in which they compare the ways in which a closed pneumatic systems and a hydraulic system operate in the same size cylinder).

ITEA Technological Literacy Benchmarks
Standard 2: The core concepts of Technology
M: Technological systems include input, processes, output, and at times, feedback
N: Systems thinking involves considering how every part relates to others.
T: Different technologies involve different sets of processes. For example, data processing includes designing, summarizing, storing, retrieving, reproducing, evaluating and communicating, while the processes of construction include design.

Standard 11: Apply the Design Process
Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed.

Conference Board of Canada Employability Skills
Communicate
CBC1 read and understand information presented in a variety of forms (e.g., words, graphs, charts, diagrams)
CBC5 use relevant scientific, technological and mathematical knowledge and skills to explain or clarify ideas

Think and Solve Problems
CBC10 assess situations and identify problems

Participate in Projects and Tasks
CBC53 develop a plan, seek feedback, test, revise and implement

Conference Board of Canada Innovation Skills
Creativity and Continuous Improvement Skills
IS3 Ask questions to assess situations, identify problems, and seek solutions

Implementation Skills
IS47 Use the right tools and technologies to complete a task, project, or assignment
As students of technology and engineering, it is vitally important to be able to communicate thoughts and ideas effectively, using a variety of tools and media. Students need to develop and use this skill throughout the course in each technology project or design challenge that is presented to them. Many technology students may be hesitant to give presentations in class; they are uncomfortable or nervous and do not clearly understand what an effective presentation looks like. Students will feel more confident talking about something they are familiar with by presenting their own ideas on their robot design and associated programming.

**Purpose**
- Present a completed robot project and associated programming.
- Rationalize and explain design decisions by communicating to peers.
- Provide an opportunity for students to explain the construction of their robot so that all students may gain a better understanding of the various robots’ components and systems.
- Create a comfortable safe environment for students to share what they have learned about robot construction.

**Payoff**
Students will:
- collaborate with each other to create effective presentations.
- hone and transfer their presentation skills for use in subsequent technical presentations.
- become familiar with design and construction decisions.
- improve conceptualization of design ideas and construction sequences.

**Tips and Resources:**
- In order to cover as many possible design and construction applications, each group of students should focus their presentation on a different component or operation of the robot e.g., touch sensor and how that component is programmed.
- Sometimes the difficult process of providing logical step-by-step instructions is made easier by the use of photos, drawings and sketches. Student groups should be encouraged to use visual displays to illustrate the form and function of their particular component.
- To ensure all members of a group are accountable for their own work, it is suggested that students provide the teacher with a list of names and functions of each member for pre-approval before working on the presentation assignment.
- Software manuals/CDs that accompany robotic kits provide examples of step-by-step instructions.
- For more information, see:
  - Student Resource, *Making a Presentation to the Class about Your Robot*.
- To make connections to course expectations, technological literacy benchmarks and employability and innovation skills, see Teacher Resource, *Key Standards for Oral Communication: Presentations*.

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Think Literacy: Cross Curricular Approaches, Grades 7-12, p. 196.

**Further Support**
- Give careful consideration when determining student teams who will present together. Ensure each student is given a meaningful task within the group and that each student shares in the workload of the presentation.
- To build student confidence, provide opportunities for a smaller audience or simply have student(s) present to the teacher.
- Limiting the number of items to be presented or the complexity of material may also increase student confidence.
<table>
<thead>
<tr>
<th>What teachers do</th>
<th>What students do</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before</strong></td>
<td></td>
</tr>
<tr>
<td>• See Teacher Resource, <em>Assessment of an Oral Presentation</em>, for an overview.</td>
<td>• Select a component or operation from their project to present.</td>
</tr>
<tr>
<td>• Review Student Resource, <em>Making a Presentation to the Class about your Robot</em>, and provide an opportunity for students to ask questions for clarification.</td>
<td>• Take note of techniques and resources during discussion.</td>
</tr>
<tr>
<td>• Ensure every member of each team has a role to play and is accountable for a particular aspect of the presentation.</td>
<td>• As a group, provide the teacher with a list of members and their respective responsibilities for pre-approval.</td>
</tr>
<tr>
<td>• Assist students in deciding which component or aspect of the robot they will choose to present.</td>
<td></td>
</tr>
<tr>
<td>• Discuss effective presentation techniques and styles.</td>
<td></td>
</tr>
<tr>
<td>• Review presentation resources such as overheads, computer presentations, posters, display boards, etc.</td>
<td></td>
</tr>
<tr>
<td><strong>During</strong></td>
<td></td>
</tr>
<tr>
<td>• Remind students to make notes on the presentations as they are watching.</td>
<td>• Present to the class one component or aspect of a robot and how it is incorporated into the assembly for their team’s robot.</td>
</tr>
<tr>
<td>• Facilitate whole class discussion about each component or aspect of robotics and how it can be linked to other components for a purpose.</td>
<td>• Participate in discussions on key ideas.</td>
</tr>
<tr>
<td>• Prepare a list of all components or operations that have been discussed for post analysis.</td>
<td>• Observe other presentations and take notes of key ideas presented.</td>
</tr>
<tr>
<td><strong>After</strong></td>
<td></td>
</tr>
<tr>
<td>• Facilitate class discussion on analysis of design ideas presented.</td>
<td>• Add notes taken during the presentations to journals or notebooks for the unit.</td>
</tr>
<tr>
<td>• Give feedback on the presentation with suggestions for further development.</td>
<td></td>
</tr>
<tr>
<td>• Point out links between the robots various functions and connections to the use of robotics in industry.</td>
<td>• Sketch ideas generated by the discussions and presentations for future robots as directed by the teacher.</td>
</tr>
<tr>
<td>• Ask students to sketch ideas they gathered from the presentations and discussions to apply to a future or extended robotics project.</td>
<td></td>
</tr>
</tbody>
</table>
Assessment of an Oral Presentation

Please keep in mind that oral communication is not a skill that can be easily taught or transferred to others. Teachers can only point the student in the right direction and coach a better performance with positive feedback. Practice should be encouraged as it is essential, both for improving skills and to make the best possible individual presentation.

Rubrics can be prepared with some or all of the following items noted below (remember to give the students a copy before hand so they know how they will be assessed). Teachers can also use the checklist located in Think Literacy: Cross-Curricular Approaches, Grades 7-12, p.196.

**Preparation:**
- Research/knowledge of their robot operations, components and/or terminology
- Process of designing and decision making
- Programming sequences
- Numbered cue cards to organize information
- Evidence of practice

**Presentation:**
- Greeting/introduction to their topic
- Clear organization (introduction, middle and conclusion)
- Clear sequence and progressive, step-by-step process when presenting their ideas
- Clear delivery (speed, pitch, tone, body language, eye contact, articulation, enunciation and time)
- Clear ideas and rationalization of design decisions

**Use of Technology and Visual Aids:**
- Visual aid is relevant to topic
- Simple, clear and effective (limit number of concepts/words on slides or visual projections, larger fonts etc.)
- Clear graphics and visuals

Remind students that technology is used to enhance but not over-shadow the presentation. (For example, some people may use presentation software transition effects because they are visually or technically appealing, but they distract the listener/viewer.) Remind them that if they intend to use equipment such as projectors, computers, etc. they must make sure equipment works beforehand.
Making a Presentation to the Class about Your Robot

To start, you and your group need to answer a few questions and make a few decisions about your presentation …

1. What topic are you presenting? What kind of information is relevant and useful?
2. Who are you presenting this information to/ who is your audience?
3. How much time do you have?
4. Who is doing the presenting?
5. Why is the information important to the audience?
6. Are you going to have visual aids or technical support? (overheads, data projection, computers etc.) If so, which ones?
7. Where are you going to make your presentation?

When you have answered or talked about each of the seven questions, provide the teacher with a list of who will do what. After approval, you will move on to the next step which is preparing the presentation.

Preparation
Keep your information short, to the point and make sure that it tells an interesting story. Prepare your talk carefully just like you would if you were doing a written report. Write the presentation out in rough and practise it until it can be presented smoothly.

• What is the point of your talk?
• What makes your robot design or robot unique or special?
• What do you want the audience to know about designing and creating a robot?
• Is your message clear and not filled with unnecessary information?

Cue Cards
These are small cards that you can hold to remind you of the key points. Write large and use short form. Do not write down every word!

Presentation
Speak clearly when you present your information. Do not shout or whisper. Change your tone and speed when you want to emphasize something or add interest. Be natural and pause at key points that you want your classmates to understand. Look at the audience as much as possible. If you choose to use a presentation board or technology to add to your talk, make sure you face the audience not the board, the TV or your computer screen.

In all presentations a clear introduction or beginning is essential (tell the audience what you are going to tell them about your robot and its design). Include a middle (tell them all the necessary details such as why you chose to make your robot in the way you did and why you programmed it in the way you did – what choices/decisions did you make and why). It must also have a conclusion or end (remind the audience of your key points and explain why your robot was the best idea).

Technology Support and Visual Aids
Sometimes we choose to add to a presentation by using overheads, data projection, DVDs, videos, music or presentation boards etc. Before using any of these technologies, make sure they add something to the presentation and do not over-shadow the words or information or distract the listener. If you use overheads or data projection make sure that the slides are simple and do not contain large amounts of information otherwise they are very difficult to read. Do not read each slide, but rather let the audience read some while you add additional information about the slides.
Key Standards for Oral Communication: Presentations

This activity is based on the following course expectations, technological literacy benchmarks and employability and innovations skills. These are to guide the teacher in developing assessment strategies and as a tool to illustrate the importance of the activity on developing a student's future career potential.

References
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International Technology Education Association (ITEA) Standards for Technological Literacy, Content for the Study of Technology (2000)
Conference Board of Canada Innovation Skills Profile (2002)

Course Expectations

Structures and Mechanisms: Grade 8 - Structural Mechanical Efficiency

Overall Expectations
By the end of Grade 8, students will:

MOV1 demonstrate an understanding of the factors that contribute to the efficient operation of mechanisms and systems;

Specific Expectations

MD3 use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (e.g., use such technical terms as velocity, velocity ratio, and efficiency);

MD5 communicate the procedures and results of investigations for specific purposes and to specific audiences, using media works, written notes, descriptions charts, graphs, drawings, and oral presentations (e.g., make a display in which they compare the ways in which a closed pneumatic systems and a hydraulic system operate in the same size cylinder).

ITEA Technological Literacy Benchmarks

Standard 2: The core concepts of Technology
M: Technological systems include input, processes, output, and at times, feedback.

Standard 11: Apply the Design Process
I: Specify criteria and constraints for the design.
L: Make a product or system and document the solution.
K: Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed.

Conference Board of Canada Employability Skills

Communicate

CBC2 write and speak so others pay attention and understand
CBC4 share information using a range of information and communication technologies (e.g., voice, e-mail, computers
CBC5 use relevant scientific, technological and mathematical knowledge and skills to explain or clarify ideas

Think and Solve Problems

CBC15 readily use science, technology and mathematics as ways to think, gain and share knowledge, solve problems and make decisions

Conference Board of Canada Innovation Skills

Creativity and Continuous Improvement Skills

IS7 Put forth your own ideas with confidence

Relationship Building Skills

IS32 Share information and expertise – explain and clarify new and different ideas
An anticipation guide is a series of questions or statements related to the topic or point of view of a particular text. Students read the questions or statements and agree or disagree with each one. The statements and questions presented to them beforehand help them engage and connect prior knowledge to aerodynamic forces as they apply to race cars.

Purpose
- Activate students’ prior knowledge and experience i.e., think about aerodynamics before reading technical information.
- Encourage personal experience-based responses.
- Promote discussions on scientific theories and principles.

Payoff
Students will:
- connect their personal knowledge and experience with the science of aerodynamic forces.
- have a purpose for the reading as it relates to the CO₂ car project.
- become familiar with the study of aerodynamics before researching the topic.

Tips and Resources
- An anticipation guide works best when students are required to read something that contains unfamiliar information. The idea of the guide is to raise students’ awareness of related issues and help them make connections with what is familiar and unfamiliar about that text.
- For electronic reading resources see the following websites:
  1. Aerodynamics in Racing Cars
  2. Build your own Race car
     http://www.gmecca.com/byorc/dtipsaerodynamics.html
  3. Aerodynamic Forces
     http://www.lerc.nasa.gov/WWW/K-12/airplane/presar.html
  4. Aerodynamics in Car Racing
     http://www.belmont.k12.ca.us/ralston/programs/itech/RaceCar/Aerodynamics_In_Car_Racing.html
  5. Race Car Photo Library
     http://www.lhmopars.com/Nats-Race1.htm
- For more information, see:
  - Student/Teacher Resource, Sample Anticipation Guide.
  - Student/Teacher Resource, Glossary of Terms.
  - Student Resource, Reflections.
- To connect this activity to course expectations, technological literacy benchmarks and employability and innovation skills, see Teacher Resource, Key Standards for Getting Ready to Read: Anticipation Guide.

Further Support
- Add an “I’m not sure” response to the guide template for students who do not feel comfortable with a definite answer.
- Provide opportunities for struggling students to contribute in a more supportive situation; divide the class into small groups of four or five and ask them to tally and chart their responses before participating in a whole-class discussion. Allow one-on-one conferences, if needed.
- Develop extended activities using related topic themes such as Design Concepts/Process, Material Selection, CO₂ Combustion, Aeronautics, Wind Tunnels, etc.
## Getting Ready to Read: Anticipation Guide

### Integrated Technologies Grade 9 CO₂ Car Project

<table>
<thead>
<tr>
<th>What teachers do</th>
<th>What students do</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before</strong></td>
<td></td>
</tr>
<tr>
<td>• Review Teacher Resource, <em>Anticipation Guide</em>: <em>Teaching Strategy</em> and determine which reading resources will be used.</td>
<td>• Listen actively and critically to understand and learn.</td>
</tr>
<tr>
<td>• Locate and provide a list of websites students can use for their research activity on aerodynamic forces.</td>
<td>• Work independently; read each statement and complete the “before reading” portion of the guide.</td>
</tr>
<tr>
<td>• Check the websites prior to beginning the activity and emphasize school policies on ethical use of the Internet.</td>
<td>• Contribute responses in class discussions.</td>
</tr>
<tr>
<td>• Create an anticipation guide or complete the sample provided. See Student/Teacher Resource, <em>Sample Anticipation Guide</em>.</td>
<td></td>
</tr>
<tr>
<td>• Distribute copies of the <em>Sample Anticipation Guide</em> to the students and explain how it is used.</td>
<td></td>
</tr>
<tr>
<td>• Have students complete the guide individually knowing they may need to justify their answers during later discussions and/or Reflection Notes.</td>
<td></td>
</tr>
<tr>
<td>• Take this opportunity to discuss key vocabulary. (See Student/Teacher Resource, <em>Glossary of Terms.</em> )</td>
<td></td>
</tr>
<tr>
<td><strong>During</strong></td>
<td></td>
</tr>
<tr>
<td>• Explain the research reading assignment and how it connects with the anticipation guide statements and discussion.</td>
<td>• Use the Internet or assigned resource.</td>
</tr>
<tr>
<td>• Have students independently research/read information verifying the guide statements.</td>
<td>• Read the assigned text and note information relating to guide statements.</td>
</tr>
<tr>
<td>• Ask students to keep the guide near as they research and read.</td>
<td>• Complete the Reflection Notes column of the guide.</td>
</tr>
<tr>
<td>• Have students use the Reflection Notes section of the guide.</td>
<td></td>
</tr>
<tr>
<td>• Engage students in class discussions, starting with a simple hand count of the numbers of students who agreed or disagreed with a particular statement.</td>
<td></td>
</tr>
<tr>
<td><strong>After</strong></td>
<td></td>
</tr>
<tr>
<td>• Lead a short discussion about how the anticipation guide helped students to better understand the text.</td>
<td>• Contribute responses to the class discussion.</td>
</tr>
<tr>
<td>• Identify and discuss the reading strategies used throughout this activity.</td>
<td>• Review each statement and discuss/note his or her pre-reading accuracy.</td>
</tr>
<tr>
<td>• Have students complete the accompanying self-reflection sheet to help assess their learning.</td>
<td>• Complete <em>Reflections.</em></td>
</tr>
</tbody>
</table>
Anticipation Guide: Teaching Strategy

1. Prepare the reading
   Option A: Teacher-directed approach:
   - Locate and/or create the reading material and distribute to students. (Choose different levels of reading according to students' needs.)
   Option B: Student-directed approach:
   - Students research on their own searching to verify some of the guide statements.
   - Develop a list of Internet sites that students can research to save on time. (Sample list of websites provided.) Be sure to check the websites before introducing them to students.

2. Create the Anticipation Guide
   - Create your own one-page Anticipation Guide or use the sample provided. You may want to create several guides relating to different articles (choose different reading levels as well).
   - Use an overhead transparency or another form of data projection of the guide to be used for class discussion.

3. Explain the strategy
   - Using data projection, refer to the Anticipation Guide and explain how it is used.
   - Explain that this is a warm-up exercise to get them thinking about the topic.

4. Demonstrate the strategy
   - Refer to the Anticipation Guide, read the first guide statement aloud and fill in the column marked "Agree/Disagree." Then, read part of the reading material and demonstrate how to complete the guide.
   - Be sure to demonstrate the use of the "Reflection Notes" column.
   - Think aloud while modeling so that students can understand your thought process.
   - This can also be an opportunity to discuss other reading strategies that may help students internalize the reading. (skim and scan, inferences, visualizing, read-aloud, making notes, etc.)

5. Completing the Anticipation Guide
   - Have students complete the guide individually letting them know they may need to justify their answers during later discussions.
   - Encourage pair/group discussion, as appropriate, while having students fill out the guide.
   - Group students according to instructional needs.
   - Discuss key vocabulary relating to the topic. (See glossary provided.)

6. Class discussion
   - After students complete the guide, engage in class discussions, starting with a simple hand-count of the numbers of students who agreed or disagreed with each statement.
   - Have students explain their responses to the class.

7. Research/read articles (print and on-line)
   - Explain the topic of the reading assignment and how it connects with anticipation guide statements.
   - Ask students to keep the guide beside the text as they read it.
   - Ask students to make notes from what they have discovered in their reading that may confirm or change their responses.
   - Have students use the "Reflection Notes" section of the guide. This is a form of "Making Notes" reading strategy.
   - Be sure to demonstrate the “think-aloud” reading strategy before they read so that students can understand the material better.

8. Review, summarize, reflect
   - Lead a short discussion with students about how the anticipation guide helped them to better understand the text.
   - Discuss the reading strategies used throughout this activity.
   - Ask students to explain why and how this helped them better understand the topic.

9. Student assessment/reflections
   - Have students complete the reflection sheet to help them assess their own learning.
   - Use reflection sheets to gain insight into how well students are staying on task.
### Sample Anticipation Guide

<table>
<thead>
<tr>
<th>BEFORE READING</th>
<th>STATEMENTS</th>
<th>AFTER READING</th>
<th>REFLECTION NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>A= Agree</td>
<td>D=Disagree</td>
<td>A= Agree</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>The principles which allow aircraft to fly are also applicable in car racing.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Drag refers to the parachute that is used to slow the car down after the race.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Air turbulence has little effect on car speed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Lap speeds are an average speed, not a top speed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Airlift/downforce principles are applied to cars as they would to airplanes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>The air moving under the car moves faster than that above it.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>The shape of the racecar has no bearing on speed. It is only for aesthetic purposes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Spoilers are not recommended in a car design due to its “spoiling” effect on aerodynamic design.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Racecars normally have a lot of ground clearance to help with keeping the car grounded.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Down force is necessary in maintaining high speeds through the corners and forces the car to the track.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Glossary of Terms

1. **aerodynamics**: the properties and forces produced on the car through the airflow moving around the car. It is the interaction between airflow and the CO$_2$ racecar.

2. **aesthetic**: the car’s visual appeal or attractiveness.

3. **airflow**: This is the movement of air around the racecar.

4. **Bernoulli Effect**: states that the pressure of air decreases as the air flows faster.

5. **drag coefficient**: the ratio of the drag on the car moving through air to the product of the velocity and the surface area of the body. It is determined by the shape and smoothness of the car. The smoother the car, the lower the drag ratio.

6. **downforce**: a vertical force directed downward, produced by airflow around the car.

7. **drag**: force that resists an object’s movement through the air. The more the object disrupts the laminar flow of air around it, the more drag is developed.

8. **friction**: a force that resists motion of an object when it is in contact with another object.

9. **inertia**: property or tendency of an object at rest to remain at rest unless acted upon by a force.

10. **flow visualization**: a feature of some wind tunnels that involves the introduction of a visible vapor into the moving airstreams. This enables racers to see how their car performs in an airstream. The effect of drag on car body features can be easily identified.

11. **laminar flow**: a straight, layered flow of air that is free of turbulent motion.

12. **lift**: aerodynamic force that pushes upward on the car as it moves through airstreams. Racecar bodies may also generate lift, positive or negative (downward force) as they move down the track.

13. **spoilers**: act like barriers to air flow, in order to build up higher air pressure in front of the spoiler keeping the rear of the car from lifting.

14. **thrust**: force that propels the car, sets it into motion, or keeps it moving (CO$_2$ cartridge).

15. **turbulence**: occurs when airflow breaks into complex changing patterns. This can cause unstable forces on the car. As the airflow moves from the front of the car to the rear it becomes turbulent.

16. **wind tunnel**: a tube-like structure where wind is produced usually by a large fan to flow over the test object. The object is connected to instruments that measure and record aerodynamic forces that act upon it.
Reflections

1. Did you find the anticipation guide helpful?

2. After reading the material, were there any surprises about your answers to the anticipation guide?

3. Do you see a relationship between science and technology? Explain your answer.

4. How will this information help you in designing your CO₂ car?
Key Standards for Getting Ready to Read: Anticipation Guide

This activity is based on the following course expectations, technological literacy benchmarks and employability and innovations skills. These are to guide the teacher in developing assessment strategies and as a tool to illustrate the importance of the activity on developing a student's future career potential.

References
The Ontario Curriculum, Grades 1-8 Science and Technology (1998)
International Technology Education Association (ITEA) Standards for Technological Literacy, Content for the Study of Technology (2000)
Conference Board of Canada Innovation Skills Profile (2002)

Grade 9 Integrated Technologies Course Expectations
Overall Expectations
TFV.02 identify ways to communicate design and research ideas and solutions through a variety of media;
SPV.03 use a variety of computer software applications for research, to solve problems, and to document the design process;

Specific Expectations
SPS.02 demonstrate understanding of the roles played by various team members in a group project.

ITEA Technological Literacy Benchmarks
Standard 3: The relationships among technologies and the connections between technology and other fields
H. Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.
J. Technological progress promotes the advancement of science and mathematics.

Conference Board of Canada Employability Skills
CBC5 use relevant scientific, technological and mathematical knowledge and skills to explain or clarify ideas
CBC6 locate, gather and organize information using appropriate technology and information systems
CBC6 access, analyze and apply knowledge and skills from various disciplines (e.g., Science, Technology and languages)
CBC29 work independently or as a part of a team

Conference Board of Canada Innovation Skills
Creativity And Continuous Improvement Skills
IS12. Look for surprising connections - be open-minded when exploring possible solutions
IS13. Listen and ask questions to understand what is new and different about others points of view
IS3. Accept and provide feedback and guidance in a constructive manner
Developing and Organizing Ideas: Webbing, Mapping and More

Integrated Technologies Grade 9 CO₂ Car Project

Effective writers use different strategies to sort the ideas and information they have brainstormed in order to make connections, identify relationships, and determine possible directions and forms for their projects. This strategy gives students the opportunity to reorganize, regroup, sort, categorize, classify and cluster their notes and ideas.

One of the first steps in the technological design process is to brainstorm ideas. Webbing and mapping are the best strategies to use when organizing information gathered through brainstorming. They are often used as forms of pre-implementation activities, enabling students to organize their thoughts and prepare for the design and planning phases. In this strategy, students gather criteria and concepts in car design and map ideas during the initial phases of the design process of a CO₂ dragster car.

Purpose

- Identify relationships and make connections among ideas and information.
- Help develop and organize ideas quickly during the design process.
- Identify key design features and design criteria of the CO₂ race car.

Payoff

Students will:
- practise critical and creative thinking strategies.
- learn a variety of strategies that can be used throughout the design process.
- organize ideas and information relating to the CO₂ car design.
- be better prepared to prioritize and plan the project.

Tips and Resources

- Strategies for webbing and mapping include: clustering, comparing, contrasting, generalizing, outlining, relating, and sorting. See Think Literacy: Cross-Curricular Approaches, Grades 7-12, p. 108.
- Commercial software programs are available for mapping purposes; these can be effective in various stages of the web mapping process or for formally organizing ideas.
- Monitor group activities and encourage full participation by all students.
- Encourage creative “out-of-the-box” thinking and recording of all ideas.
- For more information, see:
  - Teacher Resource, Mind Mapping Example.
  - Student Resource, Reflections.
- To connect course expectations, technological literacy benchmarks and employability and innovation skills, see Teacher Resource, Key Standards for Developing and Organizing Ideas: Webbing, Mapping and More.

Further Support

- Use Think/Pair/Share strategies for brainstorming sessions.
- Provide students with sample graphic organizers that guide them in sorting and organizing their information and notes e.g., cluster (webs), sequence (flow charts), or compare (Venn diagram).
- Have students create a variety of graphic organizers that they have successfully used for different writing tasks. Create a class collection for students to refer to and use.
- Provide students with access to post-it notes, markers, highlighters, scissors, and glue for marking and manipulating their gathered ideas and information.
## Developing and Organizing Ideas: Webbing, Mapping and More

### Integrated Technologies Grade 9 CO2 Car Project

<table>
<thead>
<tr>
<th>What teachers do</th>
<th>What students do</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before</strong></td>
<td></td>
</tr>
<tr>
<td>• Discuss brainstorming, webbing and mapping strategies and how they apply to the design process. Refer to Student/Teacher Resource, <em>Map Mapping: A Step-By-Step Approach.</em></td>
<td>• Listen actively and critically to understand and learn.</td>
</tr>
<tr>
<td>• Identify and illustrate several forms of organizational charts.</td>
<td>• Participate in class discussions.</td>
</tr>
<tr>
<td>• Explain how this strategy will be used in brainstorming ideas for the CO2 car design.</td>
<td>• Engage in the warm-up activity.</td>
</tr>
<tr>
<td>• Model and demonstrate the use of this strategy by introducing a warm-up activity (e.g., sample design problem such as a flashlight or other common household object).</td>
<td></td>
</tr>
</tbody>
</table>

| **During**       |                  |
| • Ask students to form groups to brainstorm and create web maps of important ideas and information regarding the CO2 car design. (See Student/Teacher Resource, *Mind Mapping: A Step-by-Step Approach.*) | • Brainstorm racecar design ideas. |
| • Be sure to have them reflect back to their research on aerodynamics (See *Getting Ready to Read: Anticipation Guide*) prior to this activity. | • Participate in collaborative/cooperative learning through group discussions in developing ideas. |
| • Encourage the free flow of ideas. Ideas that first seem “silly” may prove to be very useful. Provide an example. | • Contribute as many ideas as possible. |
| • Consider the generalization and/or categories that emerge from connections and relationships, to help identify subtopics, headings, and structure (e.g., aesthetics, car finish, aerodynamics features, wheel location, tools available, timelines, weight, etc.). | • Use computer software or simple hand sketches to develop a web map of ideas for the design. |

| **After**         |                  |
| • Have students refer to their rough notes and web map to establish design criteria and constraints and/or a scheduling flow chart. | • Review web map and identify important information and ideas. |
| • Model for students how to use the web map to create possible criteria and constraints for the design as well as a production flow chart. | • Make the connection between the web and possible ways of organizing the information and ideas into a criteria and constraints list of the CO2 car design. |
| • Have students complete Student Resource, *Reflections.* | • Create a list of criteria and constraints in designing and manufacturing the CO2 racecar. |
|                  | • Complete Student Resource, *Reflections.* |
Mind Mapping: A Step-by-Step Approach

Step 1: Identify your activity goal
- Activity: As a group, brainstorm ideas and gather information that will help you design a CO₂ racecar. Be sure that everyone understands the problems.
- This exercise will ultimately establish the criteria and constraints for your car design.

Step 2: Brainstorm ideas and information
- Brainstorming is simply a process that helps stimulate new ideas and connections.
- Everyone must contribute design ideas and information while one or more team member(s) record(s).
- ABSOLUTELY NO CRITICIZING OF IDEAS. No matter how impossible or how silly an idea is, it must be recorded.
- Laughing and having fun is to be encouraged. Criticism is not.
- Sticky notes work well at this point or you can simply record ideas on a blank sheet.
- Use words, symbols or illustrations.
- List anything that comes to mind relating to a racecar design.
- If words or ideas do not seem to fit, simply record them somewhere on the sheet. Relationships and connections may be more evident as you progress through the process.

Step 3: Organizing your ideas (Cluster/Compare/Generalize/Outline/Sort)
- Work from your central idea (CO₂ car design).
- Regroup your notes/ideas into categories.
- As an option, use different colored sticky notes to denote headings or categories that emerge from the brainstorm session.
- Establish headings and sub-groups by clustering the notes.

Step 4: Webbing
- Begin with your central idea placed in the middle of the page (CO₂ Race Car Design).
- Expand thoughts from the center like branches on a web. When one branch stops or an idea doesn't fit, create a new branch.
- As ideas emerge, print one or two word descriptions of the ideas on lines branching from the central focus.
- Allow the ideas to expand outward into branches and sub-branches. Put down all ideas without judgment or evaluation.
- Use lines, colours, arrows, branches or some other way of showing connections between the ideas.
- These relationships may be important in your understanding new information and establishing criteria for the car design.
- Break through the “8½ x 11 mentality” that says you have to write on white, letter-size paper with black ink or pencil. Use any paper you can find and tape/glue to your original if you go beyond the borders. The bigger the paper, the more ideas you can put down.
- Use coloured markers, crayons, pencils or other to distinguish or emphasize different ideas.
- Text, notes, symbols and/or sketches can be added at any time throughout this process and is strongly encouraged.
- Use computer software programs (if available) to help with the mapping.

Step 6: Keep Thinking
- Keep your mind going. As your map grows so will your ideas.
- Sometimes you see relationships and connections immediately and you can add sub-branches to a main idea. Sometimes you don’t, so you just connect the ideas to the central focus.
- Organization is continuous and can always come later; the first requirement is to get as many of the ideas out of your head and onto the paper.
Mind Mapping Example
Reflections

1. Did you find the webbing helpful in planning your design? Explain your thoughts/ideas.

2. After going through this exercise, were there any surprises regarding design ideas? In other words, were you surprised at how many ideas the group came up with?

3. What did you like best about this strategy and why?

4. How will this help in developing a good design?
Key Standards for Developing and Organizing Ideas: Webbing, Mapping and More

This activity is based on the following course expectations, technological literacy benchmarks and employability and innovations skills. These are to guide the teacher in developing assessment strategies and as a tool to illustrate the importance of the activity on developing a student's future career potential.

References
The Ontario Curriculum, Grades 1-8 Science and Technology (1998)
International Technology Education Association (ITEA) Standards for Technological Literacy, Content for the Study of Technology (2000)
Conference Board of Canada Innovation Skills Profile (2002)

Grade 9 Integrated Technologies Course Expectations
Overall Expectations
TFV.02 identify ways to communicate design and research ideas and solutions through a variety of media;
Specific Expectations
TFS.01 identify solutions to given design problems that involve existing situations or new ideas;
TFS.03 describe project ideas and solutions.

ITEA Technological Literacy Benchmarks
Standard 2: The core concepts of technology
AA: Requirements involve the identification of the criteria and constraints of a product or system and the determination of how their affect the final design and development.
Standard 9: Engineering Design
H. Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

Conference Board of Canada Employability Skills
Communicate
CBC1 read and understand information presented in a variety of forms (e.g., words, graphs, charts, diagrams)
CBC3 listen and ask questions to understand and appreciate the points of view of others
Think & Solve Problems
CBC10 assess situations and identify problems
CBC14 be creative and innovative in exploring possible solutions

Conference Board of Canada Innovation Skills
Creativity And Continuous Improvement Skills
IS3 Ask questions to assess situations, identify problems, and seek solutions
IS6 Look for surprising connections - be open-minded when exploring possible solution
Relationship-Building Skills
IS29 Understand and work within the dynamics of a group
IS33 Respect and support the ideas, approaches, and contributions of others
Teamwork is extremely important for the success of any design project. In the CO₂ Car design project, students are divided into groups/teams of four to six members. Each student is assigned a specific role and responsibility to carry out during the project. The teams meet regularly to monitor progress and maintain timelines. In these small-group discussions, each member has a role to play. The roles are rotated at each meeting. The group roles for small-group discussions give students the opportunity to develop critical thinking skills, build positive relationships, work cooperatively, and participate actively in their learning.

**Purpose**
- Encourage active participation by all members in group discussions and meetings.
- Foster awareness of the various tasks necessary in completing the design project.
- Encourage collaboration and conflict resolution.

**Payoff**
Students will:
- actively participate in small-group discussion sessions.
- understand and work within the dynamics of a group.
- become involved in a balanced decision-making process.
- share information and expertise.

**Tips and Resources**
- It is important to vary the composition of small groups whenever possible, allowing students the opportunity to work with many classmates of varied abilities, interests, backgrounds, home languages, and other characteristics.
- To encourage students to form their own groups, as well as allow for teacher-directed selections, have students choose partners and combine pairs to form the groups. This encourages students to take ownership of team formation.
- Repeat this activity many times throughout the year as students progress through the design project. This will allow students the opportunity to experience different roles and to improve on group work skills.
- Learning skills are an important part of report cards. Be sure to explain how these group activities are evaluated and reported. Assess activities through anecdotal notes and conferencing.
- For more information, see:
  - Student Resource, *Group Roles and Responsibilities*.
  - Student Resource, *Tips For Working in Groups*.
  - Student Resource, *Reflection Sheet*.
- To connect course expectations, technological literacy benchmarks and employability and innovation skills, see Teacher Resource, *Key Standards for Small-group Discussions: Group Roles*.

**Further Support**
- Some students may benefit from one-on-one conferencing prior to sharing their ideas with the group.
- ESL students may benefit from participating in groups with at least one other student who speaks the same first language.
- Although it is important to vary the composition of groups, it is also important to consider the particular needs of students.
Small-group Discussions: Group Roles
Integrated Technologies Grade 9 CO₂ Car Project

<table>
<thead>
<tr>
<th>What teachers do</th>
<th>What students do</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before</strong></td>
<td><strong>During</strong></td>
</tr>
<tr>
<td>• Review activity and prepare all necessary materials.</td>
<td>• Actively participate in group discussion and decision-making.</td>
</tr>
<tr>
<td>• Assign group teams appropriately according to skill and knowledge base.</td>
<td>• Fulfill the assigned roles to the best of their abilities.</td>
</tr>
<tr>
<td>• Have groups establish roles for each member.</td>
<td>• Record notes.</td>
</tr>
<tr>
<td>• Describe the CO₂ Car Project and the importance of on-going team meetings to monitor progress and maintain timelines.</td>
<td>• Organize and prioritize tasks.</td>
</tr>
<tr>
<td>• Distribute and discuss Student Resources, Group Roles and Responsibilities and Tips For Working in Groups.</td>
<td>• Participate in group discussions.</td>
</tr>
<tr>
<td>• Discuss each group role with class.</td>
<td></td>
</tr>
<tr>
<td><strong>After</strong></td>
<td><strong>Notes</strong></td>
</tr>
<tr>
<td>• Ask students to individually complete an evaluation of the group’s performance. (Use Student/Teacher Resource, Group Evaluation and/or Student Resource, Reflection Sheet.)</td>
<td></td>
</tr>
<tr>
<td>• Debrief with the whole class, asking students to comment on the group process. Repeat this process throughout the project as necessary.</td>
<td></td>
</tr>
<tr>
<td>• It may be helpful for each member to have the opportunity to take on all of the roles at least once. This makes members appreciate the need for group facilitation during meetings. Rotating roles can also teach members to develop their ideas before meetings, speaking only when necessary, listening carefully to others, and thinking clearly about decisions.</td>
<td></td>
</tr>
<tr>
<td>• Contribute responses in class discussions.</td>
<td></td>
</tr>
<tr>
<td>• Participate in collaborative/cooperative learning through group discussions.</td>
<td></td>
</tr>
<tr>
<td>• Complete the reflection sheet and group evaluations.</td>
<td></td>
</tr>
</tbody>
</table>

Notes
Group Roles and Responsibilities

**Chairperson:**
- "facilitates" meetings
- controls flow of the meeting
- sets the meeting agenda
- encourages members to stay focused on the topic of discussion
- interrupts a member who speaks too long or strays from the issue at hand

**Manager:**
- gathers information
- organizes all documents
- distributes documents as required
- summarizes and maintains all materials the group requires

**Recorder:**
- records all notes generated by the group
- keeps track of meeting times and dates
- clarifies ideas with group before recording
- reviews notes and reads to the group as necessary

**Spokesperson:**
- reports the group ideas to the class or teacher as necessary
- organizes and coordinates formal presentations involving group members

**Supporter:**
- provides positive feedback for each speaker
- participates in group discussion and provides input in decision making
- makes sure everyone gets a turn
- encourages group members to share ideas and listen to others’ ideas
Tips For Working in Groups

Group Process

- Identify a clear and consistent set of goals (e.g., tasks required to design and build the CO₂ racecar).
- Be sure there is an agenda each time the group meets.
- The most critical point of group work is how decisions are made. Do not rush decisions that affect the whole group. Avoid having one or two members rush or force their ideas into acceptance before the whole group has checked and commented on the idea.
- The strength of a small group depends on equal involvement and commitment among its members. Use time wisely, starting on time, and ending meetings promptly.
- Keep discussions short. When meetings last too long, group members become frustrated, impatient, and too tired to think clearly.
- Handle differences or conflicts openly and positively. If no resolution seems possible, discuss with your teacher.
- Practise both active and reflective listening.
- Summarize and reflect frequently to ensure that what is being said is being heard and understood.
- Keep all lines of communication open, before, during and after the meetings. Make sure that tasks are properly documented and assigned to group members with a firm due date.
- Keep good records of meeting discussions. It is sometimes difficult for members to recall what ideas were discussed, what they decided, and how they implemented their decisions.
- Have fun! Ideally everyone should leave the meeting feeling a sense of accomplishment.

Rules to Follow in Small-group Discussions

- Be a team player. Respect each other's ideas. Question and participate.
- No finger pointing. Address the idea, not the individual.
- Share your knowledge, experience, time, and talents.
- Keep careful and detailed written records.
- Allow only one speaker at a time.
- Let everyone have a chance to talk and be a good listener.
- Allow all members of the group opportunity to participate in the task.
- Always support each other. Encourage and reinforce creative thinking. Do not put down ideas. Show respect for others' ideas.
- Make all decisions in such a way that everyone has equal input.
- Stay on task.
- Relax, be yourself, be honest, have fun.
Reflections

Name: _______________________________  Date:  __________________

Instructions:

It is important to reflect on your experiences as a group. Your instructions are to get into your groups and discuss your experiences in completing the CO₂ Race Car. Ask yourselves the following questions and be sure to have someone in your group record your answers to the questions.

Co-operation
• Did each member work willingly and cooperatively with others in the group?
• Did everyone get along?
• Were members pleasant with one another?

Contributions
• Did each member contribute his/her fair share to group activities?
• Did all members contribute equally to the discussions?

Participation
• Did the group share many ideas?
• Were all group members on task and on topic during each of your meetings?
• Were all members involved in making decisions?

Attitude
• Did the group members listen to each other?
• Were members respectful of the contributions of others?

Organization
• Did the group prioritize and organize their work?
• Did the group manage time effectively?
• Were all documents easily accessible to all members?

Miscellaneous
• Discuss any difficulties your group experienced. How can you prevent these difficulties from happening again?
• What were the group’s strengths?
• What were the weaknesses?
• Comment on how you fulfilled the roles you were assigned.
• If your group was given the opportunity to do this assignment all over again, what would you do differently?

Select a spokesperson for your group. This person must be ready to present the results of your group discussions.
Submit your answers to the questions and the Group Evaluation with your final report.
Group Evaluation

- As a group, score your group's performance.
- Be fair and honest, and respect all individuals.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>On Topic</td>
<td>Group discussions wandered frequently and needed reminders to return on topic</td>
<td>Group stayed on task most times and completed most of the topics</td>
<td>Group mostly stayed on task and completed assigned topics</td>
<td>Group always stayed on task and thoroughly covered all necessary topics</td>
</tr>
<tr>
<td>Decision-making</td>
<td>Few members were involved in decision making</td>
<td>Some members were involved in decision making</td>
<td>Everyone contributed and was involved in decision making</td>
<td>Everyone contributed and provided leadership in decision making</td>
</tr>
<tr>
<td>Congeniality and Co-operation</td>
<td>Sometimes there was disrespect that was uncorrected</td>
<td>Some reminders of respectfulness were needed but everyone behaved appropriately</td>
<td>All group members were respectful at all times</td>
<td>Everyone was respectful and encouraged discussion and praised contributors</td>
</tr>
<tr>
<td>Summarising and Prioritizing</td>
<td>Some disorganization occurred because of lack of pre-planning which delayed some of the tasks</td>
<td>Some disorganization occurred because of lack of pre-planning but was completed on time</td>
<td>The group prioritized the discussions and was well organized</td>
<td>Group members took on leadership roles in prioritizing and organizing the tasks</td>
</tr>
<tr>
<td>Shared Responsibilities</td>
<td>Some members contributed fully</td>
<td>Most members contributed fully</td>
<td>All members contributed equally</td>
<td>All members contributed and provided leadership on specific tasks</td>
</tr>
</tbody>
</table>
Key Standards for Small-group Discussions: Group Roles

This activity is based on the following course expectations, technological literacy benchmarks and employability and innovations skills. These are to guide the teacher in developing assessment strategies and as a tool to illustrate the importance of the activity on developing a student’s future career potential.

References
The Ontario Curriculum, Grades 1-8 Science and Technology (1998)
International Technology Education Association (ITEA) Standards for Technological Literacy, Content for the Study of Technology (2000)
Conference Board of Canada Innovation Skills Profile (2002)

Grade 9 Integrated Technologies Course Expectations

Overall Expectations
TFV.02 identify ways to communicate design and research ideas and solutions through a variety of media;
SPV.03 use a variety of computer software applications for research, to solve problems, and to document the design process;

Specific Expectations
TFS.03 describe project ideas and solutions.

ITEA Technological Literacy Benchmarks

Standard 8: Apply the Design Process
H. The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.
I. Design problems are seldom presented in a clearly defined form.
K. Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other.

Conference Board of Canada Employability Skills

Communicate
CBC3 listen and ask questions to understand and appreciate the points of view of others
CBC4 share information using a range of information and communications technologies (e.g., voice, e-mail, computers)
CBC5 use relevant scientific, technological and mathematical knowledge and skills to explain or clarify ideas

Think & Solve Problems
CBC14 be creative and innovative in exploring possible solutions

Conference Board of Canada Innovation Skills

Relationship-Building Skills
IS29 Understand and work within the dynamics of a group
IS32 Share information and expertise—explain and clarify new and different ideas
IS33 Respect and support the ideas, approaches, and contributions of others
IS41 Promote personal development in others so they are better able to contribute to a team
An important phase of technological design is the reporting phase. This may include written and/or oral presentations. This lesson will prepare students for presenting their CO\textsubscript{2} project to the class.

Many students are uncomfortable in giving presentations to their class. However, presenting ideas and design solutions is a type of communication skill that is very important in the “real world”; therefore the more practice students have, the more comfortable they will be at speaking in front of groups of people. In some cases students are nervous due to a lack of knowledge regarding presentations. Through demonstration and modeling of effective presentations, teachers clearly define an effective presentation.

**Purpose**
- To clearly define effective presentation skills, including format and features.
- To create a comfortable, safe environment in which students may be successful in presentations.

**Payoff**
Students will:
- share information using media tools and a variety of technologies.
- collaborate with each other and the teacher to plan and deliver an effective presentation.
- reflect on effectiveness of presentations and discuss improvements.

**Tips and Resources**
- Demonstrate presentation techniques to establish good and bad presentation skills; recording a presentation on video is recommended.
- It may be helpful to videotape some student presentations so that students may examine the effectiveness of techniques. Videotaped exemplars can also be used to demonstrate effective presentation skills.
- For more information, see:
  - Student/Teacher Resource, *Effective Presentation Skills Checklist*.
  - Student Resource, *Peer Feedback*.
  - Student Resource, *Presentation Tips*.
- To connect course expectations, technological literacy benchmarks and employability and innovation skills see Teacher Resource, *Key Standards for Presentations: Presentation Modelling*.

**Further Support**
- Give careful consideration when determining pairs and groups presenting. Ensure each student is given a meaningful task within the group and that each student shares in the workload of the presentation.
- Some students may be insecure presenting in front of the whole class. To build student confidence, provide opportunities for a smaller audience or simply have student(s) present to the teacher. Limiting the number of items to be presented or the complexity of material may also increase student confidence.
- Plan for the use of multi-media tools. Support students to explore and incorporate video and animation software. Make students aware that relaying the message, and addressing the type of audience are the most important elements of a presentation, not the use of flashy and distracting graphics.
## Presentations: Presentation Modeling

### Integrated Technologies Grade 9 CO₂ Car Project

<table>
<thead>
<tr>
<th>What teachers do</th>
<th>What students do</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before</strong></td>
<td></td>
</tr>
<tr>
<td>• Prepare resources necessary for the modeled presentation and the final student presentations of their CO₂ projects.</td>
<td>• Listen and observe mock presentation and prepare to discuss with the class. (Alternately, demonstrate techniques as directed by teacher.)</td>
</tr>
<tr>
<td>• Prepare a brief presentation for the class that demonstrates effective and ineffective presentation techniques. (Use videotaped presentation if available.) Use the Student/Teacher Resource, <em>Effective Presentation Skills Checklist</em> as a guide for effective techniques (e.g., voice levels, posture, use of visuals, etc.).</td>
<td>• Complete <em>Effective Presentation Skills Checklist</em> based on teacher/video presentation.</td>
</tr>
<tr>
<td>• <strong>Alternatively</strong>, use the “Present” poster found in the Oral Communication section of <em>Think Literacy: Cross-Curricular Approaches, Grades 7-12</em> to lead a discussion on presentation skills.</td>
<td></td>
</tr>
<tr>
<td><strong>During</strong></td>
<td></td>
</tr>
<tr>
<td>• Using small-group learning strategies, direct students to discuss and list what they feel are important features to consider in planning the CO₂ project presentation.</td>
<td>• Actively participate in group discussion and decision-making.</td>
</tr>
<tr>
<td>• Direct teams to brainstorm and create a web map with the central theme of their CO₂ car presentation ideas.</td>
<td>• List important elements of an effective presentation.</td>
</tr>
<tr>
<td>• Distribute and discuss Student Resource, <em>Presentation Tips</em>.</td>
<td>• Create web maps; identify key features of a presentation.</td>
</tr>
<tr>
<td>• Discuss the criteria as a class.</td>
<td>• Plan, prepare and deliver their CO₂ Car Project presentations.</td>
</tr>
<tr>
<td>• Have students plan, prepare and deliver their CO₂ Car Project presentations.</td>
<td></td>
</tr>
<tr>
<td>• Consider videotaping the presentations for later discussion and analysis.</td>
<td></td>
</tr>
<tr>
<td><strong>After</strong></td>
<td></td>
</tr>
<tr>
<td>• Distribute Student Resource, <em>Peer Feedback</em>.</td>
<td>• Contribute responses in the class discussion.</td>
</tr>
<tr>
<td>• After each presentation, facilitate whole-class discussions about the presentation using the feedback sheets as a guide. Be sure to emphasize constructive feedback.</td>
<td>• Complete the feedback sheets as instructed.</td>
</tr>
</tbody>
</table>
# Effective Presentation Skills Checklist

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the topic presented clearly and logically?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the presentation clearly organized with an introduction, middle, and conclusion?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the speaker have a thorough knowledge of the subject? (Did the speaker just read from their notes?)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did the speaker gather information from a variety of sources?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did the speaker use visual aids to support the presentation?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did the speaker use appropriate tone and language for a classroom presentation?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did the speaker use effective eye contact with the audience?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did the speaker talk fluently without false starts?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did the speaker vary the volume of speech?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did the speaker vary the rate of speech?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did the speaker articulate clearly?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did the speaker use conjunctions effectively? (e.g., and, then, because)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did the speaker explain unfamiliar terms to others?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did the speaker talk for the appropriate amount of time?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did the speaker avoid unnecessary movements such as shuffling, toe tapping and shaking?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did the speaker involve the audience in the presentation?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did the speaker engage and inspire the audience?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Presentation Tips

Introduction
- Each group member must introduce him/herself.
- Each member describes their role in the CO$_2$ car project.
- A description of the project must be presented.

Body (Content)
- The group must report on all components of the car design and manufacturing (i.e., initiation phase, design phase, implementation phase, and report phase).
- Simplify wherever possible; be concise.
- Involve audience. Use questioning techniques, discussion points, and other strategies to keep the audience interested.

Conclusion
- Assign one member of the group to conclude the presentation.
- Review and reinforce the key ideas.
- Remind audience of the key points. Close with a memorable statement.
- After you conclude, be prepared to open the floor to your audience for discussion.

Participation
- All group members must participate.
- Be sure that all group members know the part they must play in the presentation.
- Discuss the topics and assist each other in preparing the presentation.

Other
- Plan and organize the presentation. Create a script to avoid confusion.
- Speak loudly and clearly emphasizing key points.
- Be presentable and well groomed.
- Use proper posture and professionalism.
- Maintain eye contact with the audience even if you are not speaking.
- Use encouraging facial expressions and gestures.
- Use multi-media tools and/or props as appropriate to reinforce key ideas.
- Be creative!
- Add humour if possible and have fun with it!!!
- Video tape the presentation for later review.
- Relax and PRACTISE, PRACTISE, PRACTISE!
Peer Feedback

Introduction
- Did all members introduce themselves and describe their role?
- Was the topic clearly identified?
- Any suggestions for improvements?

Body (Content)
- Were all project components clearly presented?
- Was there a good flow of information?
- Was there audience involvement?
- Did presenters communicate an understanding of the content?
- Any suggestions for improvement?

Conclusion
- Did the group present a good closing?
- Was there anything memorable about the closing?
- Was there an opportunity provided for questions and/or comments?
- Any suggestions for improvement?

Participation
- Did all group members participate?
- Did group members know their part in the presentation?

Overall Impact
- Did the presentation seem well planned out?
- Did the presenters speak loudly and clearly emphasizing key points?
- Was there good posture and body language?
- Did each group member seem relaxed and comfortable?
- Was there eye contact with the audience?
- Were visual aids used effectively (i.e., multi-media tools and/or props)?
- Any comments regarding creativity?
- What was your overall feeling about the presentation?
- What was the best part(s) of the presentation?
- Where can improvements be made if given another opportunity?
Key Standards for Presentations: Presentation Modelling

This activity is based on the following course expectations, technological literacy benchmarks and employability and innovations skills. These are to guide the teacher in developing assessment strategies and as a tool to illustrate the importance of the activity on developing a student's future career potential.

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International Technology Education Association (ITEA) Standards for Technological Literacy, Content for the Study of Technology (2000)
Conference Board of Canada Innovation Skills Profile (2002)

Grade 9 Integrated Technologies Course Expectations
Overall Expectations
TFV.01 demonstrate understanding of how to develop products or provide services to meet identified needs;
TFV.02 identify ways to communicate design and research ideas and solutions through a variety of media;
SPV.03 use a variety of computer software applications for research, to solve problems, and to document the design process;

Specific Expectations
TFS.01 identify solutions to given design problems that involve existing situations or new ideas;
SPS.03 share information using media tools and a variety of technologies.

ITEA Technological Literacy Benchmarks
Standard 8: The attributes of design
H. The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.

Standard 11: Apply the design process
R. Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.

Conference Board of Canada Employability Skills
Communicate
CBC2 write and speak so others pay attention and understand
CBC4 share information using a range of information and communication technologies (e.g., voice, e-mail, computers
CBC5 use relevant scientific, technological and mathematical knowledge and skills to explain or clarify ideas

Think and Solve Problems
CBC15 readily use science, technology and mathematics as ways to think, gain and share knowledge, solve problems and make decisions

Conference Board of Canada Innovation Skills
Creativity and Continuous Improvement Skills
IS9 Suggest alternative ways to achieve goals
Risk-Taking Skills
IS21 Learn from your experiences – do not be afraid to make mistakes
Relationship Building Skills
IS32 Share information and expertise – explain and clarify new and different ideas
Implementation Skills
IS50 Accept feedback and learn from mistakes