Grade 7 Explore and Investigate the UN Sustainable Development Goals

Experience 2: Engineering Design Process

This a three-part lesson will enable students to explore and investigate the UN 17 Sustainable Development Goals - - French Link

Part I of this lesson will have students work in small groups and complete a graphic organizer. Students discuss ways in which the SDGs affect their local communities and will rank in order of importance. Students will research and analyze a local problem and will create an infographic to communicate findings to the local community.

Part II, students will utilize the engineering design process through an ice melt challenge. As students acquire new information from observing their prototypes, they will be challenged with improving and learning from previous designs to create a final solution.

The Engineering Design process involves students initiation and planning solutions, performing tests, recording data, analyzing results and communicating final solutions.

This activity will deepen understanding of concepts associated with heat transfer in the environment. Students will be encouraged to integrate their knowledge of Strand C and E.

Grade 7 Long Range Plan: Model 1

Grade 7 Long Range Plan Model 2 - December/February

Overview of learning experiences – why these activities	This a three part lesson will enable students to explore and investigate the UN 17 Sustainable Development Goals - - French Link Part I of this lesson will have students work in small groups and complete a graphic organizer. Students discuss ways in which the SDGs affect their local communities and will rank in order of importance. Students will research and analyze a local problem and will create an infographic to communicate findings to the local community. Part II, students will utilize the engineering design process through an ice melt challenge. As students acquire new information from observing their prototypes, they will be challenged with improving and learning from previous designs to create a final solution.

	The Engineering Design process involves students' initiation and planning solutions, performing tests, recording data, analyzing results, and communicating final solutions. This activity will deepen understanding of concepts associated with heat transfer in the environment. Students will be encouraged to integrate their knowledge of Strand C and E. Grade 7 Long Range Plan Model 2 - December/February
Prior Knowledge / Prior Skill Set(s)	Background Knowledge and Concepts (Teacher) - Additional teacher concept support ● Teacher should be familiar with the UN Sustainable Development Goals initiative ● Plan Canada - SDGs ● Thermodynamics ● Insulators and Conductor ● Teachers should have some initial knowledge of the Design Engineering process and Expectations from Strand C and E Background Knowledge and Skills (Students) ● Students may have some experience with design and building projects and process ● Background knowledge on concepts from Strands C and E
Strand A - STEM Investigation and Communication Skills	**A1.3** use an engineering design process and associated skills to design, build, and test devices, models, structures, and/or systems **A1.5** communicate their findings, using science and technology vocabulary and formats that are appropriate for specific audiences and purposes **A3.2** investigate how science and technology can be used with other subject areas to address real-world problems **A3.3** analyse contributions to science and technology from various communities

Overview / Big Ideas/Fundamenta l Concepts	This exploration will focus on the foundational aspects of the design engineering process. Students will work through a design and build an ice melting model and will work through the steps of the EDP while linking understanding of concepts from Strand E.
Learning Goals / Success Criteria	Students will create and evaluate an ice melt model and are challenged with melting the ice the fastest. The main goal of this activity is to familiarize students with the engineering design process. Students can apply concepts in thermodynamics and energy (convection, conduction and radiation) to solve this challenge. These goals will be co-created with students and can also include classroom decided design challenges/limitations such as: limiting weight of model, amount of material, type of material etc. Create success criteria with students and share “I Can Statements” based on the curricular expectations. **Learning Objectives** ● explore how materials can affect the rate of temperature change ● use tables, chart, notebook to organize observations ● Explain background concepts including materials and heat transfers and how this relates to everyday life. ● Recognize and list common insulators and conductors ● Explain why engineering a design is an iterative process. **Ministry of Education Key Points** **STEM Skills and Connections:** Perspectives and approaches that provide opportunities for students to investigate and apply concepts and skills from all areas of learning. **Research and Experimentation Processes:** Provides students with the scientific literacy skills needed to approach scientific questions that are becoming a part of everyday life. **Engineering Design Process:** Provides students with support to plan and build solutions to problems or address needs that connect to the curriculum and the world around them.

	Hands-on, Experiential Learning: Includes hands-on, experiential learning opportunities to support classroom activities that encourage curiosity
Learning Experience(s) **A1.3**	Refer to slide deck here **Part II: Engineering Design Process** **Minds On (**10-15 minutes**)** Caterpillar Connect EDG Activity (see Appendix A: Caterpillar Connect - Engineering Design Process) **Teacher Instructions:** Print out the caterpillar from the caterpillar template and cut out each domino piece. This activity can be completed individually or in pairs. Once students connect the caterpillar parts, they will complete the table. **Student Instructions** 1. Separate the caterpillar parts on the table so that all pieces are visible. 2. Read through each description and try your best to match the description with the answer on different parts of the caterpillar. 3. Each caterpillar part will link to another to form a continuous chain until you reach the end of the caterpillar. 4. If all questions are answered correctly, the caterpillar will have all its parts! 5. Use the caterpillar to complete the table provided in the worksheet. Hint: If all pieces are matched correctly, the caterpillar will have all its parts! **Action** **Ice Melt Race - EDG Challenge** Students will use the engineering design process to have a class ice melter race. Students will complete this challenge without using a heat source such as body heat, heater, hair dryer, etc.

	Before beginning the experiment, this will be a great time to revisit variables with a focus on conducting a fair test and the benefit of having a control trial. Opportunities to make connections between heat transfers and the structure and behaviour of matter. **Experimental Materials** ● Ice cube (same size/shape for all students) (3-4 per group) ● Foil, plastic wrap, construction paper (various colours/black), wood, paper towel, bubble wrap, wax paper ● Optional: salt, sand, sugar, baking soda Materials can be altered based on availability **Challenge:** Students will be challenged to melt the ice cube the fastest with the materials provided. Students will time how long it takes to melt the ice cube completely and will compare their initial prototype with their final prototype. It is important to provide enough time for students to be able to redesign their prototype as part of the iterative design process. Alternative design challenge: ● Popsicle Challenge (Warmer Months) Apply the engineering design process to create a cooler that will keep your popsicle cold and solid for the longest amount of time. ● Hot chocolate Challenge (Colder Months) Today you are going to apply the engineering design process to keep your hot chocolate the warmest for the longest amount of time. **Set-up** 1. Provide a list or display materials that will be used for the design project. You can provide a constraint of materials or assign a budget to each group member as a prototype challenge. This could include having students "purchase" material using a budget system and/or keep the prototype under a certain weight. 2. Students will discuss as a group what materials will melt the ice cube the fastest. 3. Provide students with a copy of this worksheet to help guide students through the EDP (see Appendix B: Activity Guide for Engineering Design Process)

	Day 1 - Introduce or review concepts of heat transfers (convection, conduction, radiation) and create a list of conductors and insulators. Introduce the challenge to students and have students work on the engineering design process. Create groups of 3-4 students. Students should use the first day to plan and can prepare some materials but will not create them on this day. Students are welcome to test and touch the materials to help with the initial planning. Day 2 - Students construct their designs and can begin running tests. Instruct students to use a thermometer to measure temperature changes. Students can evaluate, redesign and reconstruct. **Consolidation (5-10 minutes)** Students present their final designs to the class and share 1 challenge and 2 successes of their designs. **Optional Extension Project:** Redesign a city block to reduce heat retention in the city (Heat Island Effect - higher temperatures in urban cities) Using an understanding of surfaces, materials, and heat transfer, imagine how you might redesign your home city to help accomplish 2 or more of the sustainable development goals. Pick a sustainable development goal that you want to incorporate into your city design. **Brainstorm** What are possible solutions to the problem? **Review potential solutions** Consider related research and current solutions Develop success criteria and constraints Consider the end-users and those impacted by potential solutions Consider material use **Plan/Select**

	Challenge: Pick a city block that you'd like to redesign. The current buildings and roads cannot be moved, however, there is room to add items, redesign rooftops, or change the material used for roads. **Create and Prototype Create a small city blueprint of the area that you have chosen to redesign. Identify areas that you will be altering in order to help accomplish the global goals that you have chosen. Use the blueprint to begin creating a prototype of your city redesign. Consider the materials you will be using to build the city block. Create a legend or key to show what real-world material would be used for the city redesign. **Evaluate and Test** Develop a test to evaluate if the solution for your prototype helps achieve your objective For example material test (heat transfer) Colour (radiation - absorption etc
Science and Technology Expectations	Overall & Specific Expectations from the Science and Technology curriculum **Stand C: Matter and Energy- Pure Substances and Mixtures** **C1. Relating Science and Technology to Our Changing World** C2.1 demonstrate an understanding of the particle theory of matter C2.8 describe pure substances as elements and compounds consisting of atoms and combinations of atoms **Stand E: Earth and Space Systems- Heat in the Environment** **E1. Relating Science and Technology to Our Changing World** E1.1 assess the social and environmental benefits of technologies that reduce heat loss in enclosed spaces or heat transfer to surrounding spaces **E2. Exploring and Understanding Concepts** E2.1 use particle theory to explain how heat affects the motion of particles in a solid, a liquid, and a gas E2.7 describe the role of radiation in heating and cooling Earth, and explain how greenhouse gases affect the transmission of radiated heat through the atmosphere

Science and Technology Vocabulary	Design engineering Prototyping Rapid prototyping Iterative Heat transfers Thermal equilibrium Insulators/insulation Conductors/conduction Radiations Heat Temperature Thermal energy Kinetic energy Absorb Radiant energy
Equipment and Materials	**Student Materials** ● Internet access (computer, ipad etc) ● Blank paper and pencil ● Chart paper or white board ● Scissors ● Ruler **Part II: Experimental Materials** Size and quantity at the discretion of teachers ● Ice cube (same size/shape for all students) (3-4 per group) ● Surface materials (foil, plastic wrap, construction paper (various colours/black), wood, paper towel) ● Extension: could also use salt, sand, sugar , baking soda ● Bubble wrap ● Newspaper ● Cardboard square ● Sandwich Bag
Timeline and Preparation	**Part II: Engineering Design Process** **Mind's On** 15 mins

	Action Design Challenge Planning 50 mins Building and Testing 50 mins **Consolidation:** Communicate final prototype 5 mins per group
Safety Considerations	Be mindful of internet use and practice standard online safety and monitor student devices. Refer to these safety resources: • Safety in Elementary Science and Technology (STAO) • Safe Activity Foundations in Education Document (SAFEdoc) Science and Technology, Grades 1-8 (OCTE) • Ontario Curriculum Program Planning – Health and Safety
Opportunities For Assessment	Achievement Chart - Knowledge and Understanding, Thinking and Investigation, Application, Communication Sample Achievement Chart Prepare an achievement chart (as seen above) that relates to the specific learning goals and aim to appeal to the interests, preferences and learning styles of the student within your classroom. Allow students to determine what a successful prototype looks like to ensure that students at the outset of learning have a shared understanding of the learning goal and criteria as learning progresses. Assessment “for Learning” and “as Learning” Provide ongoing descriptive feedback in various forms that are clear, specific, meaningful and timely to support improved learning and achievement as outlined by the Ontario curriculum resources (Assessment and Evaluation Fundamental Principles)

	Integrate assessment as learning in the form of success criteria and ensure students are setting individual goals and monitoring their own progress and thinking. This can be done by having students document prototype successes and modifications Students can also peer assess prototypes after the presentation of final products. Provide a variety of means of assessment: conversations, observations, and/or products Assessment pieces, exemplars Graphic organizers Rubrics or checklists Include opportunities to showcase engineering design process Example Engineering Design Process Rubric (see Appendix C: Engineering Design Rubric)
Instructional Strategies and Adaptability	Educators should aim to address the achievement gap between groups of students. This may include various factors such as gender, ethnocultural background, socioeconomic status, special educational needs, language proficiency, etc. As such, educators should use classroom materials and/or context that reflect the diversity of their classrooms and school community. Educators should foster a classroom environment that is inclusive and safe for all students. Refer to the Equity and Inclusive Education Strategy/Action plan Teachers should adapt the lessons based on the needs of the students in their class (Please refer to the Learning for All document and the Supporting ELL Learners Document)

Additional Supporting Resources	Heat Transfer -Crash Course YouTube video
Cross-Curricular Opportunities	Students are able to gather quantitative data (temperature change) and graph the data. Students can also create an infomercial video/presentation to "sell" or market their new design.
Future Opportunities / Next Steps	**Post Activity** Communication of Results - students can create a presentation demonstrating the EDP steps that they used in their challenge and share with the class. **Reflection** What went well with your design? What did not go well? What changes could be made to improve this process?

Appendix A: Caterpillar Connect - Engineering Design Process

Caterpillar Connect - Engineering Design Process (Student Worksheet)

1. Separate the caterpillar parts on the table so that all pieces are visible.
2. Read through each description and try your best to match the description with the answer on different parts of the caterpillar.
3. Each caterpillar part will link to another to form a continuous chain until you reach the end of the caterpillar.
4. If all questions are answered correctly, the caterpillar will have all its parts!
5. Use the caterpillar to complete the table provided in the worksheet.

Hint: If all pieces are matched correctly, the caterpillar will have all its parts!

Description	**Answer**
1. A company decides to design and produce a new basketball shoe. The company should…	
2. Brainstorm several ideas and potential solutions to the problem.	
3. A person who designs, builds or applies STEM skills to solve problems.	
4. Select the most appropriate solution and begin constructing a prototype of the design.	
5. A company finds out that a new basketball shoe design is leaving black marks on the gym floors. This is a(n)...	
6. Engineers test the prototype and analyze the results to determine next steps.	
7. Share your findings with the intended audience.	
8. When engineers develop a model or prototype…	
9. To repeat a process or do something again.	
10. A company notices that the material cost of the show has gone above the budget. This	

is a design...	
11. Identify the problem and review resources related to the problem.	
12. An original model	

Caterpillar Connect Activity - Engineering Design Process (Teacher Instructions)

Instructions: Cut out each piece of the caterpillar at the dotted line to make rectangular pieces. Mix up the pieces before handing out to students. Students can work in pairs or individually. Students will be responsible for organizing the chain so that they can complete the caterpillar body. The start block will be the face of the caterpillar and the end block will be the back of the caterpillar.

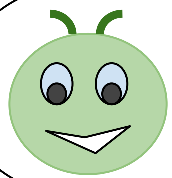
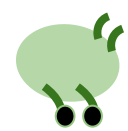
Optional: Print on coloured paper for different groups in case pieces get mixed around.

Answer Key

Description	**Answer**
1. A company decides to design and produce a new basketball shoe. The company should…	Test new design
2. Brainstorm several ideas and potential solutions to the problem.	Imagine
3. A person who designs, builds or applies STEM skills to solve problems.	Engineer
4. Select the most appropriate solution and begin constructing a prototype of the design.	Plan
5. A company finds out that a new basketball shoe design is leaving black marks on the gym floors. This is a(n)...	Observation
6. Engineers test the prototype and analyze the results to determine next steps.	Improve
7. Share your findings with the intended audience.	Communicate
8. When engineers develop a model or prototype…	Create

9. To repeat a process or do something again.	Iterate
10. A company notices that the material cost of the show has gone above the budget. This is a design...	Constraint
11. Identify the problem and review resources related to the problem.	Ask and Understand
12. An original model	Prototype

Instructions: Cut out each piece at the dotted line and mix up the order before handing it out to students.

	3. A person who designs, builds or applies STEM	**ENGINEER**	1. A company decides to design and produce a new basketball shoe. The	**TEST NEW DESIGN**	6. Engineers test the prototype and analyze the results to
IMPROVE	2. Brainstorm several ideas and potential	**IMAGINE**	5. A company finds out that a new basketball shoe design is leaving black marks on the	**OBSERVATI**	7. Share your findings with the intended
COMMUNICA	11. Identify the problem and review resources related to	**ASK and UNDERSTAN**	4. Select the most appropriate solution and begin	**PLAN**	12. An original
PROTOTYPE	8. When engineers develop a model or	**CREATE**	10. A company notices that the material cost of the shoe has	**CONSTRAINT**	

Appendix B: Activity Guide for Engineering Design Process

Teacher instructions

This template assists students with the sequence of the engineering design process. This template can be revised to add or remove guiding questions/instructions to accommodate students with different learning needs

Identify the Problem	
What is the goal of this challenge?	What are the constraints (unknowns and limitations) of this challenge?
Imagine and Brainstorm	
Material List How might these materials be used?	Based on resources, what are some possible solutions to your problem?
Design and Plan	
Rapid prototyping, Sketch a design solution below. Label parts and materials. This may be the first of many prototypes and rough and rapid sketches. Add more pages if needed.	

Create and Build Materials might have not worked as you predicted. That is okay! You may need to modify your original design. Describe some challenges that you experience while building your prototype
Test and Evaluate
Create a table and record your results and results. Add a column that includes ideas for improvement after each trial. Engineers test many versions of their prototype and reflect frequently on possible solutions. This is an **iterative** process.
Improve and make a Final Solution
Now that you've tested your prototype, sketch a final design that includes your improvement ideas. Be sure to label materials used.

Communicate and Present
What are key aspects of your design and how did the materials help solve the problem? What are some real-world applications for this type of design? What science concepts relate to this activity?

Appendix C: Engineering Design Rubric

Engineering Design Rubric

	Level 1	Level 2	Level 3	Level 4
Brainstorming Identify a variety of possible solutions to a problem	Little to no evidence of research or brainstorming observed or documented.	Some evidence of brainstorming observed and documented	Good evidence of group thinking, research, and brainstorming of ideas and concepts.	Excellent evidence of group thinking, implementing research in the brainstorming of the design.
Plan the Prototype Select a design meets the goal and identified design contraints	Little or no evidence of a design plan and/or material selection.	Some evidence of a plan with little reasoning for material selection.	Good evidence of plan and rationale for material selection.	Excellent evidence of structural planning and demonstrates strong rationale for material selection.
Build a Prototype Create a working prototype to test and evaluate the functionality	Little or no evidence of group effort to use time wisely, use materials sparingly to plan a prototype.	Some evidence of good use of time, materials and plan.	Good use of time, troubleshooting, overcoming building challenges and attempts to maximize use of materials.	Excellent use of time. Demonstrate efficiency with material use and used and/or modified plan accordingly to overcome design and building challenges.
Collaboration	Little to no collaboration and teamwork evidence. Little evidence of leadership or compromise.	Some evidence of effective collaboration and teamwork. Occasional compromises are made with some ineffective and effective criticism of other's ideas.	Good and effective collaboration and teamwork are evident throughout. Constriction is equal and fair throughout most of the project.	Evidence of excellent collaboration and teamwork. Positive attitude and strong connection between group members and contribution is equal and fair.
Communication Present a final analysis of the design to an audience	Communication of design is not appropriate for the audience and lacks crucial information.	Some key design strengths and improvements are identified	Design strengths and limitations are clearly communicated in a way that is appropriate for the audience.	Clearly and efficiently communicates strengths and limitation of design. Demonstrates strong understanding of design flaws(if any) and suggests future recommendations to improve design