The Engineering Design Process

Grade 7 & 8

WE MADE IT

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The world is facing unprecedented changes that affect climate, technology and humans at a global scale. Engineers solve these massive problems, however, the shortage of women in Engineering poses a great weakness. Without including female perspectives, our solutions may not be enough. Taking a never-been-done-before approach, Hydro One funded four universities: Ryerson, Waterloo, Western and UOIT to improve outreach to women.

The consortium collaborated with 36 high school girls to rebrand Engineering for girls. Our goal is to talk about Engineering in a way that actually relates to young women when they're making choices about their future. **WEMADEIT** is a brand, a website and now a movement, offering free innovative curriculum for grade 7&8 students designed to bring Engineering to life. Finally, there's a real tool to get kids interested in STEM careers. Join us at the forefront!

connect with teachers, training and free resources

www.wemadeit.ca/teachers

Hey Teachers!

We're so glad you picked up this booklet. **WEMADEIT** was designed to make engineering relevant for you and your students. Too often, students drop math and science courses in high school, only to discover their decision has had a profound impact on their career path. Our hope is to help keep their doors open by introducing engineering in a fun, collaborative and creative way. This project is designed to captivate your students by the power and potential of STEM – especially girls, who we've really been missing the mark with.

The **WEMADEIT** curriculum was developed as a response from working with a Youth Think Tank: 36 high school girls from Ontario who interviewed 300 of their peers and created a brand, website and campaign for girls, by girls. By combining innovative STEM curriculum, insights gathered from girls today and the knowledge and experience you have as a teacher, we're going to get students excited about engineering!

Our goal is to make science and math engaging for kids – it's not profit – so feel free to copy and distribute this material. Please share the resources with your friends and colleagues at: www.wemadeit.ca/teachers

THIS BOOKLET INCLUDES:

1. Purpose, learning goals, time & materials needed
2. Overview of Teacher & Student Participation
3. Activity & Discussion
4. Activity Worksheets for students

The Engineering Design Process

PURPOSE

Encourage your students to practice being engineers using this easy-to-use lesson plan.

Engineers are creative problem solvers who make sense of complex systems by understanding how things work and how problems arise. They are responsible for the inventions and technology we rely on everyday; everything from mp3 players and computers, to Band-Aids and artificial hearts.

In this lesson, students will learn about the Engineering Design Process – the process engineers use to find solutions to a problem. Students will address a problem by quickly developing and iterating design solutions.

This lesson serves as the introduction to the WEMADEIT curriculum. Students will use the Engineering Design Process throughout the upcoming lessons. They have to learn how to walk before they can run!.

CURRICULUM CONNECTIONS

The Engineering Design Process provides a framework for your students to solve problems by:

- Using technological problem-solving skills to determine efficiencies in a structure or to investigate a system
- Communicating their findings in a variety of forms that appeal to many audiences.

We want to give you the tools to foster excitement to investigate, explore and imagine within your students.

LEARNING GOALS

- Provide students with an understanding of what engineers do and why they're important to our everyday lives
- Teach students how engineers approach and solve problems
- Encourage your students to practice solving problems like an engineer using fun, hands-on activities in teams
- Improve students' ability and confidence to problem solve

TIME NEEDED

40 mins.

MATERIALS

- Chart paper to create anchor chart of Engineering Design Process
- Activity 1 Worksheet
- Activity 2 Worksheet

Overview of Teacher & Student Participation

	WHAT TEACHERS DO	WHAT STUDENTS DO
Before	Print a copy of Activity 1 and 2 worksheets for each group of students.	Find a space with their partner or group
	Divide students into pairs or groups of 3 or 4	
	Provide each individual, couple or group with worksheets, a pair of scissors and glue or tape	Make sure their couple or group has a pair of scissors, glue/tape and Activity Worksheets 1 and 2
During	Ask students if they know what an engineer does. Provide them with an understanding of engineering based on the insights offered in the lesson plan	Share ideas about engineering
	Discussion 1: What is Problem Solving? engage students in conversation about problem solving, make a notes about the big ideas of the Engineering Design Process	Participate in class Discussion 1, (page 7)
	Activity 1: Direct your students to match the given definitions to the steps of the Engineering Design Process	Cut out definitions and paste them onto the Activity 1 Worksheet: Steps of the Design Process
	Activity 2: Use the Engineering Design Process! Ask students to solve 1 of the 3 options given on the Activity 2 Worksheet by answering each question on worksheet 2	Choose 1 of the 3 provided problem-solving situations
	Ask the thought-provoking questions on page 9 so that students seek additional background information	Provide answers to questions on the Activity 2 worksheet
	Prompt students to question the feasibility of obtaining the materials used in their design (cost, availability) and the probability that their design could be realistically built	Question the feasibility of their design solution
After	**Discussion 2:** What are the best ways to solve a problem? Ask students to share their experiences with the class	Participate in Discussion 2
	Emphasize how the Engineering Design Process is useful to their everyday lives	

NOTES

Teachers – you really are incredible. The Youth Think Tank told us you are one of the biggest influences in their lives. They were most likely to embrace engineering if they'd had a teacher who made engineering concepts relevant to their interests (music, movies, social life, cool technology, and the environment), showed enthusiasm for engineering, and provided individualized encouragement.

References:
http://talentegg.ca/incubator/2013/09/19/8-reasons-why-a-career-as-an-engineer-is-so-great/

www.edu.gov.on.ca/eng/curriculum/elementary/scientec-18currb.pdf

http://teachers.egfi-k12.org/lesson-engineering-design-process/

For more lessons:
www.wemadeit.ca/teachers

Discussion 1:

What is Problem Solving?

Provide a simple, familiar problem (i.e. How to create a kite from paper, straws and string) and have students explain the steps that they take for finding a solution. Some may suggest drawing a picture, while others may look up ideas on the internet or in books. Some may go directly to creating without any design process at all. Most should note that the final step should be trying it out to see if it works and then making changes to make it better.

Teacher note: Many students may not make the connection that what they do naturally is problem solving... make sure to help students understand that discussing, drawing and searching for things on the internet is in fact problem solving.

ACTIVITIES

STEPS OF THE ENGINEERING DESIGN PROCESS

1. Give each student the provided Engineering Design Process Worksheets for 'Activity 1' pages 12-13, 14-15 and 16-17.

2. Ask students to match the correct description to each appropriate box. This exercise provides students with an understanding of the steps of the engineering design process and a written copy for future reference.

USING THE ENGINEERING DESIGN PROCESS

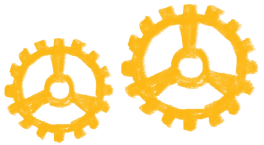
Students use their creative problem-solving skills and new knowledge of the Engineering Design Process to create a device that solves one of three problems given on pages 20-21. The 'Activity 2 worksheet' is on pages 22-23.

DIFFERENTIATION/MODIFICATION:

- Teachers can modify the activity so students can solve problems of varying difficulty and content.

- The method with which the students display their findings can vary (poster, paper model, presentation) depending on your class.

Notes for Teachers:



During Activity 2, students may need some guidance to get them started. Use specific, thought-provoking questions (examples below) to give students additional background information and help familiarize them with a particular situation. It is less important their answers are "right", the goal is for students to understand collecting lots of background information and solid research is necessary before creating a useful design.

- How much water does a cat need?
- How often does the cat need fresh water?
- What are some ways people move water from place to place?
- How could you use gravity, electricity or another force to help?
- What are some containers you've seen water in?

While teaching the 'Design' step, focus on helping the students create a realistic solution to the problem at hand. Once they have a solution, direct them towards the feasibility of obtaining the materials used in their design (cost, availability) and the probability that their design could be built if they had access to these materials and tools. To help students consider the reality of their designs, refer to the student's drawing and ask questions such as:

- How does it work?
- What material is this made out of?
- How does this connection work?
- How does this fit together?

Creative problem solving skills can take some time to develop. For some it comes naturally, while others may struggle to identify the problem or generate ideas for design solutions. It was a turning point for the Youth Think Tank participants when a teacher identified and congratulated even the smallest steps taken towards learning and practicing these new skills.

The Youth Think Tank told us they love using conversation to solve problems and make discoveries. Incorporate structured conversation into your lesson plans by asking 'how might we....' questions. As Tim Brown says, "How" assumes that solutions exist and provides the creative confidence needed to identify and solve for unmet needs. "Might" says that we can put ideas out there that might work or might not— either way, we'll learn something useful. "We" signals that we're going to collaborate and build on each other's ideas to find creative solutions together.

Discussion 2:
What are the Best Ways to Solve a Problem?

Prompt your students by asking what steps they took to solve the problem they were faced with.

1. Ask students to share their problem solving experience with the class. What steps did they take?
2. Refer to 'Engineering Design Process' activity sheet. Ask students whether they agree that these were the best steps to take. Are any missing?
3. After hearing their classmates' ideas ask students what they would change if they were to design a second, better version of their product.
4. Even though these steps are referred to as 'the Engineering Design Process', let your students know this system is used for all types of creative problem solving, from the arts to psychology. Ask students to give examples of how the Engineering Design Process

Assessment for Learning

Information from the student worksheets can be used to guide future lessons to enforce the usefulness of the Engineering Design Process. In particular, note that research is not used during this activity, meaning that students are working to identify the problem using prior knowledge and given information to design a solution.

Student Material:

The following pages are student facing materials free for you to copy and distribute. If you'd like to make changes to them please visit **www.wemadeit.ca/teachers** and find word documents there for you to edit.

WHAT IS AN ENGINEER?

Have you ever heard anyone talk about engineering and thought: “Hmmm… I have no idea what an engineer does!” Don’t worry, you’re not the only one. Most students agree that they don’t have a strong understanding of what engineers do. We’re here to change that!

The WEMADEIT lessons that your super awesome teacher just introduced to you were created with the help of students just like you – they told us what would make math and science more fun for them, and we brought their ideas to life. So get excited and keep an open mind… you’re about to discover how cool engineering can be!

p.s. If you’re loving these lessons or are interested in finding out more about engineering, check out www.wemadeit.ca a website built for students, by students!

SO, WHO IS AN ENGINEER?

Engineers come in all shapes and sizes… the more diversity, the more creative they can be!

Activity 1

Activity 1

Read all of the descriptions on the Activity 1 cut and paste sheet. Pick out the names of each step in the Engineering Design Process, cut and paste them in the grey boxes. Then decide where you think each description goes and cut and paste them into the corresponding boxes.

Describe the challenge you have to solve. Describe any criteria (the conditions that the design must satisfy) and constraints (any limitations that need to be designed around). Investigate what others have done. Remember to think about what the materials will cost and if they're available!

Does your model work? If not, what changes or improvements need to be made? Did it satisfy the criteria and constraints? Ask yourself: did your design solve the problem? If not, create a new design, build and test it until it's successful.

Design a solution

Understand the Problem

Use your knowledge and creativity to brainstorm as many ideas as possible within the criteria and constraints given. Choose the design you think will work best solve to the problem.

Using the materials you've been given, build a model of your design, thinking about the criteria and constraints.

Test and redesign

Build a model

During each step in the design process, listen to and share ideas with your team members and ask for feedback from others outside of your team. Make sure your writing and drawings are clear!

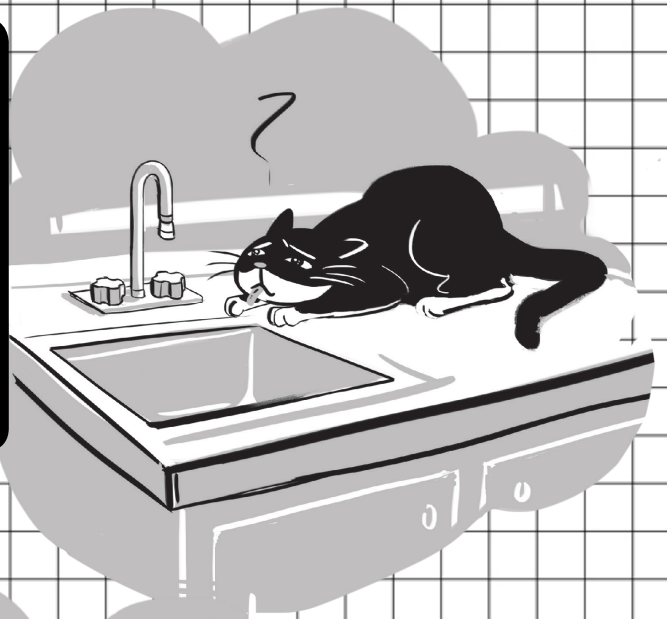
Answers for Activity 1:

Activity 2

The engineering design process helps engineers and other problem-solvers come up with creative solutions. You are an engineer. Choose one engineering problem below, and follow the steps to invent a solution.

A. Well that's not good... your new pet kitten is trapped in a ten-foot deep hole! Design a contraption to safely rescue Kitty.

B. You are going on vacation for a month and can't find anyone to feed Kitty while you're gone. You need a device that will provide Kitty with just the right amount of water — not too much and not too little.



C. You really want to finish the awesome new book you were just given to read before you go to sleep, but you don't have a bedside lamp. Kitty doesn't seem eager to help you solve this problem, so you need to figure out a way to turn off the light switch across the room without having to get out of bed.

The Engineering Design Process

1. IDENTIFY THE PROBLEM: What problem did you choose? Describe the problem and any limitations or constraints.

2. EXPLORE: What do you know about this kind of problem? What materials will you need?

3. DESIGN: Use your knowledge and creativity to brainstorm ways to solve the problem and list several possible solutions.

4. Choose one idea. On the back of this page, draw a detailed picture of the solution you chose. Label the drawing to explain what each part is made out of, how the parts fit together, and how it will work.

5. Where do you think you will run into problems with your solution? Where do you think the weak parts in your creation will be?

MY SOLUTION

Connect with teachers, training and free resources

www.wemadeit.ca/teachers