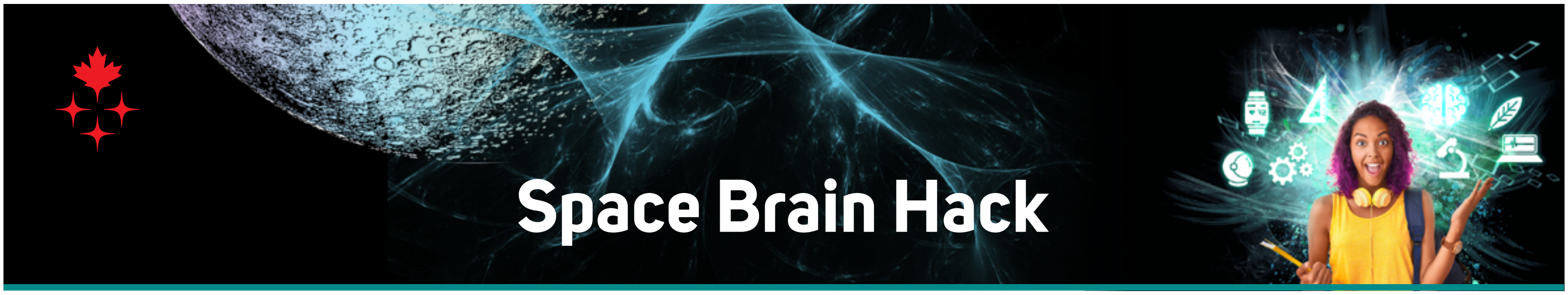

Educator Guide

This is your handbook for helping youth hack the Canadian Space Agency's (CSA) space brain by imagining solutions to open-ended problems and questions. It allows youth to explore the science, technology, engineering and mathematics (STEM) learning processes through real-world problems that connect to their interests.

You don't have to be a space enthusiast to take part in this challenge: you just need a bit of curiosity and imagination. We want youth to discover the roles they can play in space exploration now, and in the future when they study in STEM or choose a career path in STEM. Above all, this is an invitation for youth to share their perspectives and ingenuity with our experts and spark innovation.

The initiative targets youth in Grades 6 to 8, and in Grades 9 to 12. Participants are encouraged to work in teams of up to six, but individual entries are accepted.

Contents

Activity summary

Background: Canada and the global space community are growing our understanding of our changing climate and environmental issues using Earth observation technologies. Satellites have become so essential to scientists and community users that we have accepted the environmental costs they bring. As more companies build and launch clusters of small satellites, we need to think of the impacts on Earth. The theme of this year's Space Brain Hack is finding a way to lessen the ecological impact of satellites throughout their lifespan and make them more sustainable.

The challenge: **Satellites are essential to our climate change action.** Canada's next satellite mission needs to be "greener"! Select a mission phase and propose new approaches to reducing greenhouse gas emissions and/or the overall environmental impacts of these important tools.

Objective: Youth will explore what goes into a satellite mission from start to finish and propose solutions for "greening" a phase of its lifecycle. Participants will:

1) work collaboratively to design a solution to an aspect of the problem;

2) share their ideas outside of their groups to get feedback; and

3) assess the feedback and revise their solutions for the better.

Outline: **Consider using a single-day or a multi-day format with the following steps.**

1) Use the CSA-provided introductory presentation to provide context.
2) Support participants with additional resources (see end of document and toolkit), and the student worksheet to guide teams on capturing their solution and thinking process.
3) Participants work in teams of six or less for a round of brainstorming a solution and identify where they need to learn more.
4) Teams present their project idea to others (fellow students, friends, family, educators, invited experts, etc.) to gain different perspectives on their solution.
5) Teams explore the feedback, the possibilities and the limitations of their idea. The teams then fill out the worksheet outlining the solution they would like to submit to the CSA.

Curriculum themes

Science: Scientific research, critically analyzing resources, diverse knowledge systems, energy consumption, materials properties, physics of propulsion, light spectrum

Space science: Earth observation, science experiments conducted in space, technology available on missions

Environmental studies: Ecological footprint, greenhouse effect, climate change, renewable energy resources

Art: Digital arts, drawing, media, photography

Language arts and social studies: Writing up a proposal, presenting the proposal, researching, and reporting

Outcomes: Students will leave this activity with a deeper understanding of

- How satellites contribute to monitoring ecological and atmospheric conditions to help with climate change resilience.
- Factors to consider when estimating the energy, resources and time investments in mission phases.
- Types of careers and professionals involved in Earth observation.

Skills: Students will work to develop the following:

- ability to critically analyze a problem to be solved
- ability to identify and review relevant materials and ideas
- knowledge of the STEM learning process:
  - how to generate unique and creative ways to design a solution to solve the problem
  - how to prepare an initial solution
  - how to analyze or test it
  - how to obtain constructive feedback to strengthen their solution
  - how to revise their solution before submission

Getting started

In order to complete the activity, you will need:

1) the PowerPoint presentation from the website
2) student worksheets – for either Grades 6–8 or Grades 9–12
3) this educator guide, including the list of guiding questions and resources

The presentation

The presentation introduces the challenge to the participants and offers the foundation necessary to begin the thinking and analysis process. It provides background information on the topic, prompts to engage with the subject material.

Student worksheets

The worksheet must be used to enter the final solutions as described in the Submission process section below. The participants can use a blank sheet of paper and/or online tools to brainstorm and research, settle on one idea per group, and prepare the draft solution before entering it in the worksheet. If the worksheets are filled in by hand, the handwriting must be legible to be considered for the challenge. Any diagrams should be clearly labelled.

PLEASE NOTE: video links, online drives or other references to additional material will NOT be viewed. It's best to make sure all the core information is included in the worksheet.

Guiding questions and resources

Design phase:

*For simplicity we have put the prototyping and model building into the build phase; however, designs are iterated until the final version is passed for launch.

Guiding questions:

- What kind of tools and workplace would you expect a satellite design team to use? Where might their activities take place?
- Are there day-to-day actions that consume more energy than other approaches – Working at home vs. travelling to an office? Videoconferencing? Phone calls?
- What kind of tools might be used when designing the satellite or prototype?

Resources: See Appendix

Build phase:

Many of the metal resources important for building satellites come from ores and mining.

Consider taking the PowerPoint table and researching one element.

Guiding questions:

- What are the properties of the materials used to build satellites? Why are they selected? Where might there be room for innovation/change?
- What do we already know about some of the materials used to build spacecraft like satellites? Are they all present in our daily lives? Where can they be found?
- What part of the process of gathering and refining elements into the materials we need could we focus on? For example:
  - how resources are extracted (taken from Earth) and/or transported;
  - how much energy is used to refine them (make them into new materials) and to put the object together; and
  - how much water is needed throughout the process or how the process impacts water resources.

Resources: See Appendix

Launch phase:

On the road to space, satellites and their instruments are often tested on stratospheric balloon flights. Once the design is complete and tested, the kinds of rockets and their propellants that get them into orbit vary depending on weight and orbit.

Launch systems have stages and potentially release gases or materials at different levels of the atmosphere.

Launch location also makes an impact, changing the angle needed to reach orbit and potentially using less propellant or manoeuvres that require fuel.

Guiding questions:

- What kind of innovations/advances are happening in launch systems? Are all fuel types the same?
- What part of a launch process could we focus on to decrease environmental impacts? What can change and what can't?
- Canada will soon have a launch site on the East Coast for satellite missions. What potential environmental impacts could occur because of this new site?

Resources: See Appendix

Operations phase:

This is an opportunity to explore the energy costs of data storage and computing power.

Guiding questions:

- What are new ways to operate a satellite where energy resources such as the Sun can be harnessed (e.g., onboard processing)?
- Can new innovations such as AI play a role in enhancing satellite operations?
- What do we know about the way the devices we use regularly operate?

Resources: See Appendix

Decommissioning phase:

Limiting satellite waste.

Guiding questions:

- What happens to a satellite once its mission is complete? Where does it go?
- Can we reduce the waste from a decommissioned satellite by giving parts of it a new life?

Resources: See Appendix

Schedule

You can create your own schedule to run the Space Brain Hack, but options are provided below. Whatever you choose, the participants' final creations are only eligible for the challenge if submitted to the CSA no later than **Friday, February 28, 2025, at 4:30 p.m. ET** and in the format noted in the worksheet.

Participants are not limited to a single submission; multiple entries with distinct solutions are welcome.

Note: Participants may need access to the Internet or the library to research various topics as they design their solution.

Flexible activity formats

The challenge offers a flexible format allowing you to select the depth and length of the engagement with the participants for in-person or virtual sessions.

A minimum of 2.5 hours is required to run the activity using the single-day approach. However, the challenge can run over multiple sessions based on whatever works for you.

2.5-hour format

- The educator gives an introduction using the presentation provided. – 30 minutes
- Brainstorming. – 1.5 hours
  - The participants explore the resources, ask questions, bounce ideas around and come up with an idea.
  - The educator (or an invited expert*) takes time with each of the teams to discuss their solution and provide some feedback for improvement.
- The participants incorporate the feedback into the design or idea. – 15 minutes
- The participants fill out their worksheets. – 15 minutes
- The educator submits their worksheets to the CSA following the process described below.

Multi-day format (minimum time of three days with 60- to 90-minute sessions)

Day 1

- The educator gives an introduction using the presentation provided. – 30 minutes
- The participants brainstorm and explore the worksheet while considering the additional resources. – 30 to 45 minutes

Day 2

- The participants continue their brainstorming and research, settle on one idea per group and prepare their draft solution on a blank sheet of paper and/or using online tools. – 30 to 40 minutes
- The educator (or an invited expert*) takes time with each of the teams to discuss their solution and provide some feedback for improvement. – 20 to 30 minutes

Day 3

- The participants incorporate the feedback into the final design or idea. – 20 minutes
- The participants fill out their worksheets with their final version, and clearly identify the changes they made based on feedback in the final "Reality Check" question. – 15 minutes
- The educator submits their worksheets to the CSA following the process described below.

Virtual format

The challenge can also be completed in a virtual format using your preferred web-conference platform:

- The educator shares the presentation.
- The educator provides youth with the fillable .pdf version of the worksheet to help guide their thinking.
- Participants break out into teams using a breakout room function or work individually to brainstorm ideas using a virtual collaboration tool.
- They present the ideas to the educator, invited expert* or the entire group for feedback.
- They go back to the team, finalize the idea and fill in the final .pdf worksheet to be submitted.

* Note: Educators are encouraged to invite local experts to inspire their students. They can consult the Canadian Space Ambassadors program list to find experts in their region.

Submission process

For the challenge, we ask that **educators submit** the completed worksheets in .pdf format to the online form on the CSA website.

1) On the **first page**, we ask the participants to identify their project (project title). This is required to participate. Please double-check this section.
2) Participants also need to fill out **ALL the sections** to the best of their ability, so we're able to get the clearest picture of the solution they submit.
3) If the worksheets are filled out by hand, it's important that the handwriting be legible to be considered for the challenge.
4) Attach the illustrations (if any) to the file.

Please note: It is mandatory to use the worksheet provided by the CSA for this activity. Entries that do not follow the worksheet format will be disqualified.

IMPORTANT:

- Save each document, using your name (as the educator) following this format: firstname_familyname.
- If you submit more than one file, simply add a number at the end (e.g. firstname_familyname1, firstname_familyname2).
- Submissions are due by **February 28, 2025, at 4:30 p.m. ET**.

Project assessment criteria

All the eligible entries will be assessed based on the age group and criteria listed below.

Should several entries get the same grade; a draw will be held to determine a winner.

Grades 6 to 8	
Assessment Criteria	**Description**
Communication	A. How complete is your solution? Does your solution accurately address the problem? Does it solve only part of or all aspects of the problem? B. How clear and well described are your diagram and explanations? How easy is it for others to read and understand your explanations and diagram?
Innovation	A. Does your solution approach the problem in a new or innovative way? Is it different from current solutions and/or is it a variation of something that has already been done but applied in an innovative way? B. Is the solution adaptable to Earth? What modifications were envisioned to adapt the solution?
Validity	A. How are the constraints and limitations of the problem considered in the design of your solution? B. How sound are the scientific concepts applied to your solution? Is the solution logical and realistic?
Critical thinking	A. Is there evidence that your solution was modified following feedback? If no changes were made, was an explanation included?

Grades 9 to 12	
Assessment Criteria	**Description**
Communication	A. How complete is your solution? Does your solution accurately address the problem? Does it solve only part of or all aspects of the problem? B. How clear and well described are your diagram and explanations? How easy is it for others to read and understand your explanations and diagram?
Innovation	A. Does your solution approach the problem in a new or innovative way? Is it different from current solutions and/or is it a variation of something that has already been done but applied in an innovative way? B. Is the solution adaptable to Earth? What modifications were envisioned to adapt the solution?
Validity	A. How are the constraints and limitations of the problem considered in the design of your solution? B. How soundly are the scientific concepts applied to your solution? Is the solution logical and realistic?
Critical analysis	A. What limitations of your solution are identified? How have you discussed the limitations? B. What feedback did you receive? Is there any evidence that your solution was modified following this feedback? If no changes were made, was an explanation included?

We hope your group enjoys the Space Brain Hack! If you have any questions, please reach out to us at stimjeunesse-youthstem@asc-csa.gc.ca. We want to make sure your experience is rewarding, too.

APPENDIX

Design phase resources:

Spotlight on energy efficiency (canada.ca)

Energy Consumption in Research Labs

General Lab Function:

- Solar panels for electricity: Solar Photovoltaic Energy in Buildings (canada.ca)
- Insulation to reduce energy for heating: Keeping the Heat In (canada.ca)
- Building energy efficient windows: Windows, doors and skylights (canada.ca)
- Using ENERGY STAR features and appliances: Buying ENERGY STAR certified products (canada.ca)
- Heating and cooling with a heat pump: Heating and Cooling With a Heat Pump (canada.ca)
- Other details on energy efficiency in buildings: What is an energy-efficient home? (canada.ca)

Equipment for designing the satellite:

- Batteries: Battery Innovation (canada.ca)
- Battery-electric powered equipment: Canada cuts carbon pollution with funding for Glencore Canada Corporation project (canada.ca)

Build phase resources:

Videos and articles on Energy Efficiency in Canada – ENG and FR

Mining research and innovation at CanmetMINING (canada.ca) FR

Videos and articles on Energy sources and distribution networks FR

Sustainable Procurement: What it is and why does it matter? (English only)

Launch phase resources:

About stratospheric balloons | Canadian Space Agency (asc-csa.gc.ca)

How bad is rocket pollution? Fly to the stars to find out | CBC News

Space launches from Canada will be allowed soon, transport minister says | CBC News

Operations phase resources:

Ground Stations

- Ground stations have the potential to be operated using clean energy, which would include running missions using wind, hydro, solar and geothermal sources.
    - Wind Energy and Wind Map: Wind Energy | Canada's Wind TRM
    - Solar panels for electricity: Solar Photovoltaic Energy in Buildings (canada.ca)
- Biofuels: Biofuels (canada.ca)
- Batteries: Battery Innovation (canada.ca)

Life Span

- Satellites are already designed to withstand the most extreme elements and are expected to last long periods of time before degradation.

Decommissioning phase resources:

Rethink Your Consumer Habits – Protect Nature Challenge - Canada.ca

- Rethink – Consider sustainability in satellite design. Select materials that are sourced responsibly and consider whether certain materials are necessary at all.
- Refuse and Reduce – Limit excess materials used in the design.
- Reuse – Find ways to use scrap materials produced from construction of the satellite.
- Repair and Repurpose – Prioritize repairing elements of the design, when possible, rather than wasting early prototypes or models. Must also consider that satellites need to be safe to deploy, and long-lasting to limit space debris, so follow this guideline accordingly.
- Rot – In the case of satellites, creating composting products is not possible. But, perhaps the satellite could be built from materials that could disintegrate safely.
- Recycle – Decommission the satellite to be brought back down to Earth and reuse it for future missions. Certain requirements must be met for this, such as durable materials in the product, limited damage or repairs of pieces, etc.
- Recruit – Find ways to encourage other satellite builders and space services to build sustainable, durable and environmentally friendly satellites.

Circular Economy: The circular economy: more value, less waste. (youtube.com)

- Constructing a satellite that can be returned to Earth and used for other missions, construction projects, etc.
- What is the circular economy? https://www.youtube.com/watch?v=aOpzwgYvk3Q
- How does the circular economy impact business? https://www.youtube.com/watch?v=EaDsPQKONOE