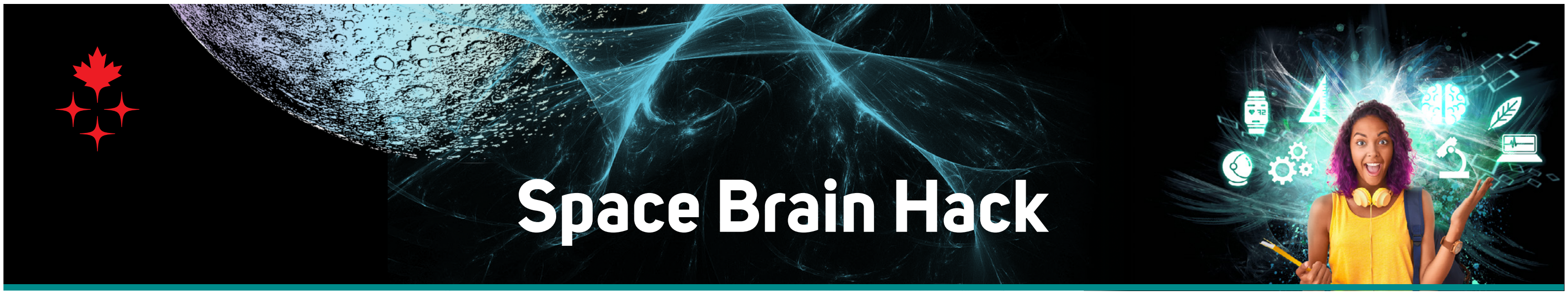

Educator Guide

The Space Brain Hack is one of the Canadian Space Agency's annual opportunities to involve youth in Canada's exciting Moon and other space missions. Youth are invited to tackle the challenges that current professionals in the space sector are facing through a problem-solving and design-thinking exercise. 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 related to the Lunar Gateway and other space missions. It allows youth to explore the science, technology, engineering and mathematics (STEM) learning processes through real-world problems the CSA is looking to solve.

You don't have to be a space enthusiast to take part in this challenge: you just need a bit of empathy for yourself and your fellow humans. 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 experience and curiosity and help expose our experts to fresh perspectives and spark innovation.

The initiative targets youth in Grades 6 to 8, and in Grades 9 to 12. For each of the age groups the topic remains the same, **but the assessment criteria and worksheets used for the projects differ**. 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 preparing for the Artemis and Lunar Gateway missions that will take humans back to the Moon and later on to Mars. With these ambitious goals come changes to space missions that will require new approaches for producing fresh, nutritious food for the astronauts, which is the theme of this year's Space Brain Hack.

Objective: Youth will explore food production on Earth and in space to design and develop a solution that takes some constraints into account. Participants can work collaboratively to design a solution to an aspect of the problem; share their ideas outside of their groups to get feedback; assess the feedback and their solution applicability and limitations; then revise their solutions, which can be submitted to our annual Space Brain Hack challenge.

The challenge: **You are a future lunar astronaut on a one-year mission on the Moon. Design a food production system that creates fresh food for you and your fellow crewmates, full of flavour and nutrients, with the least possible waste.** Keep in mind the constraints presented to you and generate enough fresh food to supplement the packaged food for a crew of four adults.

Outline: **Below is an outline of the activity you can use for either a single-day or a multi-day format.**

1) Use the CSA-provided introductory presentation to introduce the challenge.
2) Support participants with additional resources (see end of document), and the student worksheet to guide teams on the challenge solution format.
3) Participants work in teams of six or less to brainstorm a solution and record their ideas in the accompanying student worksheet.
4) Participants present their project idea to others (fellow students, friends, family, educators, invited experts, etc.) to gain different perspectives on their solution.
5) Participants 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.

Curriculum themes

Science: Scientific research, critically analyzing resources, diverse knowledge systems, food literacy, food safety and preparation, food security in remote environments (including space), plant science, understanding environmental conditions to promote plant and crop growth

Space science: Moon and the lunar environment, lunar (Artemis) missions, space food, growing food in space, science experiments conducted in space, technology available on missions, nutrition for astronauts, food production system, growing food in different environments

Health: Mental well-being, physical health, positive motivation, family and community, assess healthy choices, connection between food, nutrition and physical health

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

- Types of food that astronauts currently have access to in space
- How plants are grown on Earth and in space as well as what is required for plants to grow, survive, and thrive
- What a food production system is and how the lunar environment impacts food production
- Types of careers and professionals involved in efforts to produce food in space

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 modify and 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 in the annex

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, constraints for the project and a chance to engage with the subject material. *Speaker notes* are included, as well as *discussion questions* to help generate interest and reflection. The participants are designing a solution to help feed four astronauts fresh food to supplement the packaged food on a year-long mission on the surface of the Moon. The participants will thus have to ensure their solutions respect the environmental limitations. These constraints and limitations as well as various considerations are listed on the last two slides, and it's recommended to leave the last slide up on the screen as they work on their ideas.

Student worksheets

There are two different worksheets. Select the one that is relevant to the participants' grade level: Grades 6–8 or Grades 9–12.

The worksheet **must** be used to enter the final solutions that are to be submitted as a .pdf file 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.

Optional additional activities

You can supplement the Space Brain Hack challenge with the CSA's Interplanetary Farming activity. In this activity, the students will learn about what types of food would best suit farming on the International Space Station, the Moon, and Mars. They will also create a diorama of how they imagine growing food will be like on a planet other than Earth.

In addition, Master Chef: Mars is an activity that could help students understand requirements and considerations for food sent on long-duration missions.

You can have the students explore the Deep Space Food Challenge – a competition to develop new technologies to produce food for future space missions while expanding opportunities for food production on Earth. This challenge was launched by the CSA in partnership with NASA in January 2021. It is currently in the final phase and the winners will be announced in spring 2024. The titles of the proposals submitted are listed on the website and would help inspire students.

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 **Wednesday, February 28, 2024, at 2:00 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 a design or 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 **Wednesday, February 28, 2024, at 2:00 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.

ANNEX

Additional guiding questions

Introduction to food in space:

- How do you think space food is different from what you eat on Earth?
- Why is space food packaged the way it is for astronauts' consumption in space?
- What tools and technologies are available aboard the Space Station when it comes to food?
- What types of foods are available to the astronauts?
- Are there any requirements for the food to be sent to space?

Food production:

- Can you think of a garden in a schoolyard and what you need to add or do for plants to grow?
- Do all plants grow the same way? If not, what have you noticed where, when and at what speed different plants grow?

Lunar environment:

- How will the Moon's environment impact plant growth? Does the Moon's environment prevent certain plants from growing?
- Is there any way to stimulate plant growth on the Moon, taking into consideration what we know from our observations of plant growth here on Earth?

Solution:

- Can you think of potential hurdles to your solution?
- Does your diagram accurately represent various aspects of your solution?
- How would your solution change if you need to adapt it to be used by people here on Earth?

Limitations:

- What are the limitations of the solution you described? Can you think of conditions or situations when it may not work?
- Would you require additional or new technology for it to be operational on the Moon?
- What are the pros and cons of your solution?

Additional background information

International Space Station (ISS)

The ISS is a self-contained environment. There are several tools/technologies on the ISS for the astronauts regarding food:

- There is a water dispensing system on the ISS. The water can be dispensed at hot or lukewarm temperatures into packages.
- There is also a food warmer on the ISS that heats via conduction through metal plates—astronauts can put their rehydrated meals, cans, or retort packages in the food warmer before they eat it.
- Currently, astronauts on the ISS don't have access to fridge, freezer, stove or dishwasher.

The food on the ISS is stored in a pantry format. This means that there is no planned daily menu, and astronauts can pick and choose what foods they would like to eat.

As there is no access to fridge, freezer, stove, or oven on the ISS, this means that all the food that is shipped to the ISS needs to last for 1.5 years outside of a fridge because the food is sent to the ISS before the astronaut arrives.

Currently on the ISS, 93% of the water is recycled. Water is a precious resource aboard the Station and very heavy to carry to space, hence, whatever water gets expelled is collected in a purification system. Initially, the water was delivered to space in water-filled bags, however, since the installation of the system in 2010, the water is purified in real time aboard the Space Station.

We can assume astronauts on the Lunar Gateway and/or the lunar base will be bound by similar limitations mentioned above.

Food production

Nutrient Delivery System (aka Plant Food): It is possible to grow plants without soil as long as nutrients are provided. Plants can be grown without soil using a hydroponic or aeroponic system.

Hydroponics: Hydroponics is a method of growing plants in water instead of soil. Water used for hydroponics has nutrients dissolved into it which plants can use for photosynthesis and growth. Using water instead of soil can have many potential benefits such as:

- Bugs and pests are reduced
- Good system for growing plants where soil is not available: on a space station, space base, or Antarctica
- Controllable water—no overwatering or water waste
- Easily adjust the water's pH to suit the plant's needs
- No weeds

Using a hydroponic system on the Moon may be helpful as transporting nutrient-rich soil would be heavy and expensive. Water, on the other hand, has multiple uses and would likely need to be transported to the Moon anyway.

Aeroponics: Aeroponics is a method of growing plants without being submerged in water or rooted in soil. Instead, the plant roots are in a suspended dark chamber and is periodically sprayed with a nutrient solution.

Benefits of using aeroponics may include:

- Fast plant growth
- Good system for growing plants where soil is not available: on a space station, space base, or Antarctica
- Controllable water—no overwatering or water waste
- Less nutrients and water needed
- Increased oxygen exposure for the roots

Using an aeroponic system on the Moon may be helpful, as spraying the roots with a nutrient solution would help the plants grow in low gravity. In low-gravity environments, water does not "flow" like it does on Earth and therefore may cause difficulties with the plant roots evenly contacting the water.

Moon

Light and temperatures: Plants have different light and temperature requirements, depending on where they are adapted to grow. Temperature directly effects plant growth by either slowing down or speeding up plant life processes. Warm temperatures help germinate seeds and may result in increased transpiration, respiration, and photosynthesis of the plant.

Plants use sunlight for photosynthesis; however, artificial light systems can also be used. Light-emitting diodes (LEDs) are a popular choice for artificial light for indoor plants. LEDs work by emitting certain frequencies of light which is beneficial to plant growth or providing the full visible spectrum of light. The visible spectrum of light is the light that humans can see with the naked eye.

Water: While water ice has been discovered on the Moon, it is not currently available in a form or large amounts that could be used to produce food.

Lunar regolith: Samples of lunar regolith (soil) were brought to Earth during the Apollo program. There have been experiments on growing plants in those samples, and scientists have been successful in growing plants from seeds. They were not as robust as plants grown in Earth soil. The experiments showed that the plants were under stress, similar to the plants that grow in harsh environments here on Earth. Hence, at this time, we do not have a sound method of growing plants in lunar regolith that are just as nourishing as the plants grown here on Earth.

Additional resources

The following toolkits are provided for convenience and are not required reading to complete the project. Educators may want each team to consult one or two links within the kits and share their findings with the rest of the group.

- Toolkit for educators and youth – Food production
- Toolkit for educators and youth – Artemis and the Moon