Designing and building a Mars habitat

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Overview: In space, many of the requirements we rely on for survival are not met. Therefore, to live and work in space, we have to take with us everything we need, and devise ways to recycle or dispose of the waste we produce. This lesson prompts students to think about resources that enable human survival, and how do we provide them for crewmembers living in a Mars based habitat.

Goals:

1. Begin by discussing what humans need to survive on Earth and then extrapolate the list to what humans need in space. What is essential for survival in space and what can be removed to save weight and money?
2. Discuss how the requirements are important during the design and construction process. Design the habitat by drawing a draft on a paper.
3. Build a model habitat out of cardboard and tape.

Materials:

- Worksheet 1
- Worksheet 2
- Large piece of paper and markers for drawing habitat design
- Cardboard, scissor, and tape for building a habitat model

Part 1) List essentials that enable human survival on Earth.

Question: what do we expect for our everyday life on Earth?
Answer:

- Shelter from weather – a home and clothing
- Clean drinking water and a sanitary living environment
- Breathable air
- Nutritious food
- Medical care
- Adequate sleep and leisure time
- Physical well-being
- Feel free to brainstorm more

Part 2) List special challenges for living in a Martian environment.

Question: When it comes to human survival, what challenges are unique to a Martian environment? How and why would a habitat on Mars be built differently than one built on Earth?

Answers:

- Shelter from radiation, micro-meteorites, dust, the surrounding vacuum and the extreme temperature environments
- Significant reduction in standard water use, increased water recovery and recycling. This includes hygiene facilities that use very little water – for the astronauts to wash their clothes and bodies, and a toilet

- Breathable air – a way to either recycle old air (oxygen provision, carbon dioxide and contaminant removal) or supply new air.
- Nutritious food – to be either brought and stored or produced in the habitat
- Medical facilities for minor problems such as cuts, rashes, infections, toothache and motion sickness, and for more serious problems such as broken bones, kidney stones and heart attacks
- Exercise facilities addressing cardiovascular, muscle and skeleton maintenance
- Temperature regulation systems to compensate for the temperature extremes. Surface temperatures on the Moon can be as low as -270 °C in permanently shadowed craters at the poles, and higher than 121 °C in the full sun at the lunar equator.
- Communication systems (contact with mission control as well as family and friends on Earth)
- Recycling or disposal of liquid waste (urine) and solid waste (general garbage, feces). This needs to be done under the guidelines of planetary protection.
- Monitoring systems for the life-support systems (air- and water-quality monitoring, radiation dose measurements)
- A food preparation and eating area
- Work areas for exploration experiments (geology, biology, chemistry, etc.). This is a requirement to justify long-duration space exploration.

Worksheet 1: list the top 5 things (could be more) that a Mars habitat needs to address (eg. radiation, communication lag) and order them in terms of importance.

Worksheet 2: how much food, water, and power would be needed to sustain a crew of 5 for a year on Mars? And how would these resources be acquired (resupplied from Earth, or produced locally on Mars)?

Possible extension: psychology

Any crew on a long mission, for example to Mars, will be farrr from home, and isolated from their loved ones and confined in a small space with other crew members. Identify potential psychological effects of long term living in space, and discuss with students ways to mitigate these effects. Incorporate these solutions into the habitat design.

Part 3) Design a habitat that could address the concerns in part 2)

Draw a draft of your habitat design on paper.

When designing, think about:

How many rooms will the habitat have? What is the function of each room? How will the habitat be deployed/constructed (materials, construction method)? Design the habitat such that the challenges in **Worksheet 1** can be addressed.

Design constraints:

When a space habitat is designed, it is important that it should be:

- Safe – this is the most important consideration
- Robust – strong, reliable, durable, requiring minimal maintenance
- Lightweight – the average fridge weighs 100 kg and is clearly not an option in a space habitat
- Launchable – the different elements have to fit an available rocket in terms of weight, shape and power requirements
- Effective – it must do what it was designed to do
- Affordable – space exploration is expensive, so all steps to reduce costs without compromising performance and safety must be taken.

Tips for designing an effective habitat

How can we meet the requirements of a space habitat under the constraints that are imposed? This is done by:

- Using a modular construction system, beginning with the essential features and adding 'rooms' as needed for particular purposes (e.g. research or space for more crew)
- Developing technology to utilise the resources on Mars, e.g. making bricks using Martian soil (regolith) or using the underground caves on Mars for habitats
- Recycling (air, water, waste, parts of the landing spacecraft for construction, the oxygen and hydrogen in extra rocket fuel for water production)
- Miniaturising as many things as possible, standardising all tools, power connections, etc.
- Making areas multipurpose, e.g. a dining table that folds away so that the space can also be used for other purposes.

Part 4) Build a habitat model based on your designs.