Analyzing the Mars Sample Return Program

Companion Lesson to X-STEM All Access Lesson "Returning to the Moon"

Grade/ Grade Band: High School	**Topic:** Engineering

Brief Lesson Description: Students will consider how tradeoffs play a role in prioritizing criteria when selecting a solution to a problem by exploring the scientific goals of the Mars 2020 and Mars Sample Return program. Students will assume the role of various stakeholders, determine the criteria that best meet their needs, and then prioritize criteria as a group to determine how a solution will be selected.

Performance Expectation(s):

HS-ETS-1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Specific Learning Outcomes:

Students can use technical information to determine the goal of a mission and infer criteria that would meet this goal.
Students can communicate the needs of a specific stakeholder group and use these needs to prioritize criteria.

Narrative / Background Information

Prior Student Knowledge:

This lesson assumes that students are familiar with criteria as they relate to the engineering design process as a means to determine what solution is optimal. Additionally, students should have a basic understanding of signs of life), geological processes, and climate factors.

Science & Engineering Practices:	**Disciplinary Core Ideas:**	**Crosscutting Concepts:**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progress to explanations that are supported by multiple and independent student generated sources of evidence consistent with scientific ideas, principles, and theories. ● Evaluate a solution to a complex, real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradoff considerations.	**ETS 1.B: Developing Possible Solutions** ● When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering and Technology on Society and the Natural World** ● New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Possible Preconceptions/Misconceptions:

-Complex decisions about multiple solutions require engineers to weigh the tradeoffs of multiple options, but these may be over simplified by students.
-There is a tendency for students to overemphasize the pros of their favored solutions and the cons of less favored solutions.
-Students often fail to organize their discussions/analysis of competing criteria in favor of going with their "gut"

LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:

NASA is currently working on the Artemis mission for humans to return to the moon. This program is the first step in the quest for people to travel to Mars.

"Would you want to be the first person to walk on Mars? Why or why not?" Have students discuss this question first with a partner and then as a whole class.

Explain that before this can happen, there are many scientific objectives that must be met and technological challenges that must be overcome. To learn more about this, introduce students to Dr. Moogega Cooper of NASA using the following biography:

"Dr. Moogega (pronounced Moo-ji-gae) Cooper received her B.A. in Physics from Hampton University in 2006. She then enrolled in Drexel University where she received her Masters and Ph.D. in Mechanical Engineering with a concentration in thermal fluid sciences. Her dissertation studies involved non-equilibrium plasma sterilization of spacecraft materials so it was a logical transition to work for the Jet Propulsion Laboratory's (JPL) Planetary Protection Group. She has been at JPL for 11 years, working on spacecraft to include Mars Science Laboratory, In Sight, Mars 2020 as the Lead of Planetary Protection, and the Europa Lander concept. She is currently the 353N Group Supervisor of the Biotechnology and Planetary Protection Group. Her passion is education and outreach as well as developing sterilization capabilities that could potentially be applied to the returned sample from Mars."

Returning to the Moon with Dr. Moogega Cooper

After watching the video, ask students to share what they learned.

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:

During the video, Dr. Cooper explained that the Mars Rover will be collecting samples on the surface of Mars to send back to Earth. Today, we will be learning about these samples and then consider how scientists at NASA should go about choosing the best samples to bring back to Earth.

Start by handing out the Student Answer Sheet if printed -or- posting the google document to a LMS.

Have students complete part 1: Sampling Mars. In this part of the activity, students will read a short summary explaining what the mission's science goals are and how samples are collected. They will then consider the samples that have been taken and how one might select which ones will come back from Mars.

After giving students time to work on this section, ***discuss prompts as a class.*** If you are limited on time, focus on the even numbered prompts in the class discussion.

EXPLAIN: Concepts Explained and Vocabulary Defined:

Tradeoff: *a balance achieved between two desirable but incompatible features; a compromise.*

Explain to students that after samples are collected by Mars 2020, NASA scientists will have to decide which of the 20 samples should return to Earth. This will require scientists looking at TRADE-OFFS to find the best possible samples to return.

What do you think the term trade-off means? Have students discuss with a partner and then share as a class. Come to a class consensus of what they think the term means. Have students record this in their notes.

Next show the Trade-Off video. After the video, have students discuss if there are any adjustments that should be made to the group definition. Make these changes as needed.

Based on this definition, ***What kind of trade-offs do you think that the NASA science team might have to make when selecting which samples to bring back from Mars? Why might these exist?*** Have students generate their own ideas first and then discuss with a partner and then the class.

In order to deal with trade-offs, one important strategy that teams use is to prioritize criteria. This allows them to make informed decisions about what solutions meet the criteria.

ELABORATE: Applications and Extensions:

Today we will practice working with trade-offs by completing a simulation.

Group students into groups of fours. Assign each member of the group one of the following roles:
1)Biologist
2)Climatologist
3)Geologist
4) Astronaut

Explain to students that they are going to look at the goals for each of these different roles and determine what criteria that they think should be used to determine which samples should be returned to Earth.

Direct students to complete Part two of the Student Answer Sheet. Provide sufficient time for each member of the group to complete their assigned section. Make sure that student's know that they will be responsible for sharing their findings with the rest of their team.
(*Differentiation note: you can have students regroup to work in roles if students need support, i.e. pair 2 biologists together)

Next, have teams collaborate to complete part 3. Each student will share their three criteria with clear reasoning as to why they matter. After all team members have shared, have them work together to prioritize or rank their criteria and then complete the two analysis questions in part 3.

Discuss each group's results for part 3 as a class and then move on to the reflection questions.

EVALUATE:
Formative Assessment:
Formative questions throughout this lesson are found in ***italics***.

Summative Assessment:
Part 4 of the Student Answer Sheet provides students an opportunity to demonstrate their understanding of trade-offs by completing a constructed response question.

Elaborate Further / Reflect: Enrichment:
Students can be part of the Mars Sample Return Mission by sending their name on the rover/lander that will go to Mars. Students should visit this site to add their name to be sent to Mars.

Students may also explore current and future science missions by visiting the NASA Science Directorate site. Students can explore the wide variety of science topics and vehicles used to study space and Earth Science. Students can compete to have their own opportunity to develop a science experiment for NASA as part of the Future Engineers NASA Tech Rise Challenge.

SOCIAL EMOTIONAL LEARNING ACTIVITY

CASEL Competency Addressed: Relationship Skills/Social Awareness

During the XSTEM video, Dr. Cooper said her best advice for everyone is to surround yourself with people who you trust and have your best interests in mind.

To help students consider this idea, start by having students create a list on a sheet of paper of the humans that they have had interactions with over the past week. Tell them to think about people at home, school, their community activities, job etc. Give them several minutes to generate a complete list. Next, ask students to circle the names of people whom they trust. Finally, ask students to highlight the circled people who they think have their best interests in mind. The people who are both circled and highlighted are this student's support team.

After students have identified the members of their support team, ask them to reflect upon and then discuss the following prompts:

1) How did you decide whether or not you would circle (trust) someone on this list? What characteristics do they demonstrate?
2) How did you decide whether or not you would highlight (have your best interests in mind) someone on this list? What characteristics do they demonstrate?
3) What kinds of problems/situations would you go to these people for?

Finally, ask students to consider how they can keep track of this list for times when they feel like they need support. Possible ideas include a text thread, notes in a planner, social media, etc.

INTERDISCIPLINARY CONNECTIONS/IDEAS

Mathematics: Students can consider the mathematics associated with the Mars missions by using the Math Curriculum by NASA. In addition to the Mars Math resource, there are Mars related problems in volumes 2, 3, 6, 8, and 9.

Economics: Students can investigate the idea of trade-offs by studying the Allocation of Resources and Goods. Here is an example lesson for this concept.

Materials Required for This Lesson/Activity			
Quantity	**Description**	**Potential Supplier (item #)**	**Estimated Price**
	No Materials Needed for this Lesson		

For questions please contact info@usasciencefestival.org