Marsbound

Overview:

In this card-game-based activity, youth will work in teams to design a mission to a planet. Youth will determine goals and work within engineering constraints (mass, power, money) to build a spacecraft.

Goals:

- Learn how scientists and engineers work together to design exploration missions.
- Learn about engineering constraints.
- Problem solve and work as a team to design an exploration mission to another planet.

Time Required: 1-2 hours

Materials:

For each group:

- Marsbound Game Boards
- Marsbound Game Cards
- Calculators (optional)
- Mars Goals and Objectives handout

For each student:

- Scratch paper
- Pencils
- Student worksheet

Procedure:

1. If not already done, remove the green cards from the decks before giving to students.
2. Introduce the activity and tell students: “Scientists and engineers work together to design missions to other planets. First, we will think like scientists. Remember our “Strange New Planet” activity? What questions did you have about that planet? Work with your group and discuss 2-3 questions you had.” (if you did not do the “Strange New Planet” activity, proceed to step 3, have students select some goals and objectives from this list)
3. Tell students, “NASA scientists do the same thing. They observe objects, learn about what we know and come up with new questions. Show the Mars Goals

and Objectives handout. These are the current goals for Mars Exploration and some examples of different Science Objectives used on real NASA Missions." Give students a chance to look at the Objectives, you might read over them out loud. Some possible discussion questions might be:
    a. Are any of the questions you came up with on this list?
    b. Why might we want to know about the atmosphere?
    c. Are you surprised by any of the questions?
4. Instruct students to work with their group to come up with 3 science objectives they want to answer with their mission. Write their objectives down on their worksheet.
5. OK, now it is time to "build" our mission. The activity we are going to use was developed as a part of the Mars Exploration program, but the same general process is used for any of the exploration missions. This mission is a robotic mission. Robots are the first explorers we send to other objects in our solar system. Humans have only been to the Moon!
6. Review the 3 types of missions (flyby, orbiter, lander/rover). Ask students, "Which of these missions would work the best to answer your questions?" Mark your choice on your worksheet.
7. Introduce the idea of engineering constraints, tell students: "Engineers have to work within limits. For example, each mission receives a budget from NASA. They only have so much money to spend and the projects have to stay within that budget. You will also have a budget to work with. Cost for your spacecraft components is shown with the dollar sign (shown in millions of dollars, i.e. $10 = $10 million). Another constraint is power requirements. There are no gas stations or power outlets in space! Your spacecraft will need to supply enough power for all the components. Power requirements are indicated with the lightning bolt symbol. Finally, we need to launch our spacecraft into space onboard a rocket. If the mass of our spacecraft is more than what the rocket can lift, it will not launch successfully. Mass is show with the weight icon." (the key for these symbols is in their Mission Notebook).
8. Remember – Science is why we go. Maximize the science of the mission by getting the most "stars" possible. (*you could make this a contest with a prize for the group that get the most stars*)
9. Give students about 30-45 minutes to build and finalize missions. Circulate and provide guidance as needed. Hints to design the mission:
    a. Start with their goals and choose the instruments (dark blue cards 13-25 and yellow cards 28-30) needed to meet those goals.
    b. Then add rover and lander components if needed (pink cards 26-27, gray cards 31-34).
    c. Card 35 can be added to any mission if you choose!

   d. Add in the required components (purple cards 36-38 and light blue 39-41), notice there is only 1 or 2 options for these components.
   e. Now start working with the constraints, add the power requirements for your spacecraft and select a power supply (orange cards 7-12).
   f. Add up the mass of your spacecraft and select a booster (red cards 1-6).
   g. Now add up the cost of your spacecraft, are you under budget? What can you change? What sacrifices do you need to make?
   h. Make modifications, check mass, power, and budget until you meet all the constraints.
10. Optional: The green cards can be used to provide modifications for groups – if you have a group that is moving quickly give them a budget cut…if you have a group that is struggling, give them a budget increase. (Do not use these modifications if you are giving prizes for the most science return as some groups would have an advantage.)
11. Have groups present their missions: tell their original 3 goals, type of mission, what sacrifices they made to design their mission, science return (stars) and anything else they would like to share.
12. Optional: After the group presents, roll a die to determine if there was a successful launch or a failure. For example, if the rocket works 4 times out of 6 and they roll a 1-4, they successfully launch. If they roll a 5 or 6, there is a launch failure.
13. A budget of $250 million dollars is considered an “average” level of difficulty.
14. Optional / Extension: Have students draw a picture of their spacecraft! See links at the end of this lesson for examples of spacecraft drawings.
15. Possible Discussion Questions:
   a. What do you think would be the hardest part or parts of planning a mission to Mars? Why?
   b. Do scientists and engineers get everything they need and/or want when they are planning their mission? Why or why not?

Common problems / Additional guidance:

- Pay attention to Optional and Required components.
- With power supply, students need EITHER one of the Solar Panels (cards 7-9) and the Battery (10), OR the Fuel Cell (11), OR the Radioisotope Power System (12)
- Millions of Dollars – while the original intent is to show the costs of the components in Millions of dollars, this can sometimes be confusing. Simply the math by imply dropping the “millions”. The sample budget might be $250 and each component would cost the value indicated on the card.

Adapted from the following lesson:

- Mars Education at Arizona State University, Marsbound! https://marsed.asu.edu/lesson_plans/marsbound

Learn more about NASA Exploration Missions:

- NASA Solar System Exploration Missions: https://solarsystem.nasa.gov
- NASA Mars Exploration Missions : https://mars.nasa.gov
- Pictures of NASA spacecraft with labels:
    - Cassini: https://www.jpl.nasa.gov/infographics/cassini-spacecraft-2
    - New Horizons: https://pluto.jhuapl.edu/Mission/Spacecraft.php#Payload
    - Perseverance: https://mars.nasa.gov/mars2020/spacecraft/instruments/
    - Mars Rovers (cartoon): https://spaceplace.nasa.gov/mars-rovers/en/

Mars Goals & Objectives

Mars Exploration Program Goals :

1. Determine if life ever arose on Mars
2. Characterize the past and present climate of Mars
3. Characterize the geology of Mars
4. Prepare for Human exploration

Sample Science Objectives for Mars Missions :

Below is a list of some of the science questions being studied by Mars scientists that can be selected as mission objectives—questions to be answered.

- What does the surface look like?
- What kinds of surface features are on Mars and how did they form?
- How old are the surface features on Mars?
- How are Martian surface features different from surface on the Moon?
- Have the surface features been eroded by wind or water?
- How have the surface features on Mars changed over time?
- What types of volcanoes are on Mars?
- Does Mars have moving continental plates?
- Were the northern plains on Mars once a huge ocean?
- Why is the northern hemisphere smooth and flat, while the southern is cratered?
- What are ice caps on Mars made of?
- How do the ice caps change throughout the Martian year?
- What are the dark lands/ features seen on Martian ice caps?
- What formed the canyon systems on Mars?
- Did water ever flow through the canyons?
- What is the atmosphere made of? Clouds?
- Are there storms? What are the storms on Mars like?
- Is there a magnetic field?
- How much solar radiation reaches the surface?