Virtual Field Trip Activities
Journey to the Extreme: Your VIP Pass to Mars

Grade Level: Grades 6-8
Subjects: Science, Technology, Engineering, Art, Math

Time Frame:
• Approximately 2-3 class periods for the pre-Virtual Field Trip activities
• 60 minutes for the Virtual Field Trip
• From 1 class period to several multi-day periods, depending on the options you choose, for the post-Virtual Field Trip activities

Overview:
Before participating in the Virtual Field Trip (VFT), students will test their prior knowledge about Mars; become familiar with basic information about Mars through research; determine how technology plays a role in NASA's Mars Science Laboratory mission; and explore their dreams for the future.

During the VFT, students will learn first-hand about the science and technology behind NASA's Mars rover, Curiosity and its mission on Mars. Students will have the chance to participate and ask questions and walk away with a deeper understanding of the science and technology involved in getting Curiosity to Mars and landing it safely and getting information – and music – back from Mars. They will also hear from Leland Melvin, former professional football player and astronaut and current NASA associate administrator for education, about the importance of dreaming big and pursuing their passions.

After the VFT, students will apply what they learn about the science and technology of the Mars rover, Curiosity mission to a variety of STEM activities related to the various concepts that astronauts, scientists and engineers need to take into consideration when planning a mission to Mars. They will also explore how the Arts are a key element in the design process and a critical piece of innovation, as well as a way for people to express and realize their dreams.

Background for Teachers:
As educators, you promote the disciplines of science, technology, engineering, and math (STEM) with your students. STEM education is essential in order to enable students to identify the ways in which the four disciplines represented by the acronym STEM are intertwined with one another on a daily basis. STEM + Art = STEAM. By combining STEM with art and design, STEAM seeks to inspire true innovation. Both the topic and the speaker in this Virtual Field Trip provide the opportunity for you to do just that in an interesting, engaging, and accessible format for students.

This Virtual Field Trip, hosted by Leland Melvin and David Lavery, lets teachers and students embark on a study of NASA's Mars Science Laboratory mission within the context of a STEAM curriculum. In this case, the science portion focuses on the disciplines of earth/space science. This is combined with an investigation of the technology involved in sending vehicles into space and successfully landing them on other planets, using rovers to explore Mars, and transmitting a growing body of information back to Earth. The arts are addressed through design activities as well as activities focused on using music, and other media, to explore and express one's dreams.

As you lead students through the activities in the lesson, you are encouraged to help your students look for the STEAM connections that are woven throughout the Virtual Field Trip (VFT) and pre- and post-VFT activities.

Virtual Field Trip Presenters:
Leland D. Melvin, NASA associate administrator for education, is responsible for the development and implementation of education programs that strengthen student involvement and public awareness in NASA's scientific goals and missions. He leads the agency in inspiring interest in science, technology, engineering and mathematics (STEM) through NASA's unique mission, workforce, facilities, research and innovations.

Melvin received his undergraduate degree in chemistry from the University of Richmond and his Master of Science degree in materials science engineering from the University of Virginia. He began his NASA career as a research scientist at NASA Langley Research Center in Hampton, Virginia, in 1989. In 1998, he was selected to become an astronaut by NASA's Johnson Space Center in Houston. Melvin completed two Space Shuttle flights: STS-122 in 2008 and STS-129 in 2009. He flew both of his missions aboard *Atlantis* and has logged more than 565 hours in space. Prior to his graduate studies and joining NASA, Melvin was a National Football League wide receiver for the Detroit Lions and Dallas Cowboys.

David Lavery is currently responsible for two Mars Exploration missions (2008 and 2009), the design and development oversight of the next generation of robotic Mars exploration spacecraft, the NASA Astrobiology Field Laboratory, and the Mars Advanced Technology Program. For over a decade, Mr. Lavery led NASA's Telerobotics Technology Development Program, with responsibility for content and direction of robotics and planetary exploration research efforts. Under his leadership the program was transformed into a world-class robotics technology and systems development program impacting NASA flight programs, other government robotics projects, and the entire robotics industry. Mr. Lavery's current professional commitment and involvement includes the creation of the NASA Robotics Alliance Project (RAP) to inspire K-12 students in robotics and serving as a National Executive Advisory Board member of FIRST Robotics.

Pre-VFT Activities (Engage):

1. <u>What Do You Know about Mars?</u>

- Write the word Mars on the board and give students 1-2 minutes to brainstorm (write down or draw) everything that comes to mind when they think about Mars.
- Use the following quiz as an anticipatory guide on Mars. For each of the questions, students should answer Fact or Fiction.
- Option: You may choose not to reveal the answers and revisit the questions as a post-Webinar activity that can be used as an assessment.

Mars: Fact or Fiction? Quiz

1. Ancient rivers once meandered across Mars' surface. (Fact)
2. Ancient Romans, Egyptians and Babylonians recognized Mars as a planet. (Fact)
3. Of the eight known planets, Mars is the fourth largest. (Fiction; it's the second smallest)
4. Mars has two moons within its gravitational pull. (Fact)
5. NASA's fastest trip to Mars has taken about three months. (Fiction; it's taken about twice that long.)
6. In winter, nighttime temperatures on Mars can drop as low as -191 degrees Fahrenheit. (Fact)
7. In 1938, a radio theater presentation of a book about Martians invading Earth caused widespread panic. (Fact)
8. Like Earth, the poles of Mars are covered in ice. (Fact)
9. Mars is known as the "Red Planet" because its surface is red. (Fiction; it's actually the color of butterscotch pudding.)
10. Mars has about the same land area as Earth. (Fact)
11. The Martian "day" is about half as long as a day on Earth. (Fiction; it's about half an hour longer.)
12. The Valles Marineris, a system of canyons on Mars, is the largest rift system in the Solar System. (Fiction; Earth's Rift Valley and Baltis Vallis on Venus are larger.)
13. One of Mars' moons is moving closer to Mars and scientists think that one day it will crash into Mars. (Fact)
14. Mars is named for the ancient God of War. (Fact)

2. Mars' Surface
   - Ask students what the surface of Mars looks like. Accept all answers.
   - Break students into pairs or small groups and assign each group one of the following Martian landforms to research:
     - impact crater
     - volcano
     - river valley
     - river bed
     - dry lake bed
     - polygonal ground
     - lava flow
     - sand dune

- fractures
- wind streaks

- Have each group present its landform to the class as a whole. Presentations should include at least one image of the landform.
- Discuss which of these landforms is present on Earth. Invite students to consider how familiarity with these landforms might help NASA scientists working on a mission to land a rover that can study the Martian environment and transmit data back to Earth.
- Have students create models of Mars' surface to familiarize themselves with the obstacles NASA has had to overcome during its Mars Science Laboratory mission.

Extension:

- Have students further investigate the surface of Mars through the creation of impact craters.
- Divide students into small groups and give each group a cake pan (13 x 9") with flour and balls of various sizes. Fine red sand can be used to spread a thin layer over the flour to represent the "red planet."
- Have students drop the balls onto the pan from a height of two feet.
- Students should measure the width of the crater and the length of the splatter from each ball.
- Students can then research the various craters on Mars, determine why Mars has so many craters, and compare the number of craters on Mars to the number on Earth, which has far fewer.

3. <u>You've Got to Design It!</u>

- Explain to students that NASA's Curiosity rover is a mobile science laboratory designed to search areas of Mars for past or present conditions favorable to life, and conditions capable of preserving a record of life.
- Have students work in small groups to design their own Mars rover. Students can create visual designs or build their rovers using materials they deem suitable. (Legos or other building sets with interlocking pieces may be the best options.)
- Students should incorporate the following principles in their designs:
    - It must be able to move around. Optional: It must have a way to right itself if it tumbles over on rugged terrain.
    - It must have an apparatus for picking up items to "analyze."
    - It must have a way generating the electricity it needs to run.
    - It must have a way to receive and transmit information.
    - It must have a way to capture images.
    - It must have a way to measure temperature.
- When students have completed their designs, have each group present its design to the class.
- Students can vote on the best rover and/or create a class design that incorporates the best features of various groups' designs.

- Have students visit NASA's website (http://mars.jpl.nasa.gov/msl/mission/rover/) to learn about the technology and design behind the Curiosity rover.

4. Just How Do They Get That Off the Ground?
   - Explain to students that they are going to investigate the problem of propulsion, which scientists from NASA must solve to get a rocket or spaceship into space.
   - Divide students into small groups and provide each group with the following materials: a small plastic car, a variety of balloons, masking tape, a 6-foot piece of string (kite string thickness), and a 2-inch piece of drinking straw.
   - Explain to students that the goal is to figure out how to get the balloon to carry the small plastic car from the floor to the top of the 6-foot string.
   - Ask for three volunteers to help demonstrate the basics: One student must first blow up a balloon and hold the end closed. A second student must then tape the 2-inch piece of straw to the one side of the balloon and the small plastic car to the other side of the balloon. A third student will step on one end of the string to anchor it to the ground. The second student will place the kite string through the 2-inch piece of straw while the first student keeps hold of the end of the balloon to keep the air in. The third student should hold up the end of the string in a straight line perpendicular to the ground. The student holding the balloon will then let go and the balloon will move up the string. The goal is to get the balloon to go as high up the string as possible.
   - Students should replicate the process in their small groups. After their first attempt, they should discuss possible ways to get the balloon to go higher (use a bigger balloon, blow up the current balloon even bigger, use a different shape balloon, etc.).
   - Allow time for each group to complete three trials. For each attempt, they should take notes on their approach and results.
   - Have a class discussion about what students learned needed to be done in order to be successful.
   - Introduce the concept of propulsion and provide a definition (e.g., the process of driving an object forward). Ask students how this concept applies to the experiment they just conducted.
   - Ask how the concept of propulsion might apply to the work of NASA. Explain that NASA scientists need to apply this principle in order to give their spaceships enough boost to break free from the gravity of Earth.

5. Aim High
   - Share with students the following quote from President John F. Kennedy's famous 1962 Moon speech: "We choose to go to the moon. We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard."
   - Ask students what they think this quote means. Discuss possible interpretations. Guide students to understand that sometimes the greatest rewards come from the most difficult challenges.

- Ask students to brainstorm at least five things they would like to accomplish in their lives and rank them from easiest to most difficult.
- Have students pick one goal at the hard end of the spectrum and write down 3 actions they can take to help them achieve that goal.
- Ask students to share their responses with a partner or small group.
- Explain that during the Virtual Field Trip students will learn about how the speaker dared to dream big and worked hard to achieve his goals. Provide students with a brief biography of Leland Melvin.
- As a class, compile a list of questions students would like to pose to the presenter regarding his personal journey and his advice on achieving one's goals.

Virtual Field Trip (Explore)

- Participate in the Virtual Field Trip (VFT) together. If you are watching live, it will likely take about an hour.
- Ask students to pass in their questions/points of interest for the speakers. Submit your questions via the chat function on Livestream . These questions can also be used after the VFT for subsequent discussion.
- Encourage students to actively listen and jot down additional questions they may have as well as facts they learn about NASA's Mars mission and Mars in general.
- Ask them to pay particular attention to the presenters' descriptions of the technology and science behind the Mars mission to help with post-VFT activities!

Post-VFT Activities (Explain and Extend)

1. <u>Perfect Timing, Perfect Aim</u>
    - Explain that one of the biggest challenges in getting the Curiosity rover to Mars had to do with timing and aim. Because both Earth and Mars are in motion, NASA's scientists had to make calculations for where both Earth and Mars would be at the time of the proposed landing.
    - Divide students into small groups of three. Have one student hold a pencil with a bull's-eye target (roughly 6 inches in diameter) taped to it. Have another student three feet away and use a ping pong ball to aim at the target. Have the student with the ball pay attention to how much force s/he uses when trying to hit the target. Have the third student record the number of attempts it takes to hit the target and how much force was applied to the ball.
    - After 5 attempts, students should discuss their results (number of unsuccessful vs. successful attempts) and what factors contributed to success. Students should understand that it takes relatively little effort and force to hit a stationary target from this distance.
    - Have the students conduct the experiment again with the student holding the ball remaining stationary while the student holding the target slowly moves further away (starting at a distance of three feet but eventually reaching a distance of six feet) and then slowly moves closer. Have students record the number of successful vs. unsuccessful attempts as well as the amount of force that was applied to the ball.

- After 5 attempts, students should discuss their findings. Students should consider how the amount of force applied to the ball changed. They should also discuss other factors that the "shooter" took into account when trying to hit the moving object.
- Have students repeat the experiment a third time with both the student holding the ball and the student holding the target slowly rotating in a circle to mimic the planets' rotation. They should record and discuss their findings on this third attempt.
- Bring the full class together to compare findings and discuss all of the factors that they took into account when attempting to successfully hit the target.
- Have students watch "How Do You Get to Mars?" to provide context on the challenges of getting the Curiosity Rover to Mars (http://www.nasa.gov/multimedia/videogallery/index.html?media_id=121464191).
- Discuss how the experiment relates to the Mars Curiosity mission. What factors did NASA scientists have to address in order to successfully land the Curiosity rover and what technologies did they use?

2. Only a Day Away

- Explain that the Mars rover's average speed is 30 meters per hour, but it can go up to 90 meters per hour. It's expected to average 200 meters per day in its exploration of Mars. NASA's communication with the Curiosity Rover takes 14 minutes each way, so one transmission between the rover and command takes 28 minutes. This is very uneconomical, so the scientists devised an efficient communication strategy: they give the rover all of its directions for the day on the previous evening. Then they wait to see where it is moves prior to giving it the next day's directions.
- The rover landed about 10 km from the base of Mount Sharp. This map gives the location of Curiosity when it landed: http://www.nasa.gov/mission_pages/msl/multimedia/gallery/pia14294-anno.html.
- Have students review the information about where the Mars rover Curiosity landed and then pick out another place of interest on the surface of Mars where they would like to direct the rover.
- Taking into account the distance and speed of travel for the Curiosity rover, students should design a mission to navigate the rover to their desired destination. They must remember that directions can only be given once in the morning. Students should create a journal that includes the mission for each day, including detailed directions, and the expected results of each day's mission (starting and ending locations) as well as the total amount of time the trip will take.
- After students have completed and shared their journals, have them compare their plans and estimates with a map of the rover's travels during the 56th Martion day, or sol, of its mission: http://www.nasa.gov/mission_pages/msl/multimedia/pia16200.html. Were students' expectations of the distance the rover can travel in a day accurate? Why or why not?

3. You Designed It, Now Refine It!

- Explain that now that students have learned more about the successful NASA mission with Curiosity, they will have an opportunity to revisit and refine their original rover designs. Emphasize that the design process is iterative and it often takes many attempts before a final successful design is achieved.
- Students can first watch and discuss a short video about the Mars landing and rover: http://www.nasa.gov/multimedia/videogallery/index.html?media_id=105929071.
- Have students work in small groups to brainstorm and discuss what they've learned about the rover from the pre-Virtual Field Trip activities, the Virtual Field Trip, and the video.
- Next, have students revisit their original rover designs and choose one or more features to tweak or embellish. As a reminder, provide students with the following criteria:
    - It must be able to move around. Optional: It must have a way to right itself if it tumbles over on rugged terrain.
    - It must have an apparatus for picking up items to "analyze."
    - It must have a way generating the electricity it needs to run.
    - It must have a way to receive and transmit information.
    - It must have a way to capture images.
    - It must have a way to measure temperature.

  Students can focus on these or choose a new feature to add to their rover.
- Students should redesign their rovers and articulate the reasoning behind the revisions they chose to make.
- When students have completed their designs, have each group present its new design to the class. In their presentations, students can also explain what other changes they would make if given more time.
- Conclude with a discussion about the nature of the engineering design process. Reinforce that developing a successful technology or product involves a lot of research and many stages of design, testing, and refining.

4. NASA's Spinoffs
    - Ask students, "What do sunglasses, ear thermometers, and joysticks have in common?" Give them a minute to brainstorm and then ask several student volunteers to share their ideas.
    - Explain that all of these products are the direct result of NASA's research in support of its missions to space.
    - Introduce the following definition: "A NASA spinoff is a technology, originally developed to meet NASA mission needs, that has been transferred to the public and now provides benefits for the Nation and the world as a commercial product or service."
    - Have students work in small groups to investigate an addition NASA spinoff using one or more of the following sources:
        - http://www.nasa.gov/pdf/527945main_345978main_Shuttle_spinoffs.pdf
        - http://spinoff.nasa.gov/

      Students should focus on the reason the technology was originally developed as well as how the technology has been transformed for everyday, public use.

- Invite each group to share information about the spinoff they learned about.
- Explain to students that they will now create their own spinoff based on a technology used in the Curiosity mission or another NASA mission. Their technology should be designed to improve their lives in some way. It can be a completely new product or one that is somehow an improvement on an already existing NASA spinoff.
- Once students have designed the product, they should create an advertisement or commercial in which they tout all the advantages of their new product.
- Students can present their products to the class or another class. Peers can vote on the product they would be most likely to purchase/use.

5. Let's Move to Mars
    - Explain to students that terraforming is the process of transforming an inhospitable environment into one where humans could live. When scientists consider whether it might be possible for humans to live on other planets, they consider Mars to be the best bet. This is because the atmosphere of Mars at present, which is essentially one with very little oxygen, mirrors that of Earth many years ago. However, in order to make Mars livable for humans, we would need to create an atmosphere where there is none. Mars already has carbon, oxygen and nitrogen, the key components of Earth's atmosphere, but they are currently trapped in icecaps and the Martian soil.
    - Explain that one idea for terraforming Mars is to create solar-powered greenhouse gas producing factories. These factories would mimic the process of photosynthesis that takes place on Earth, adding CFCs, methane, carbon dioxide, and other greenhouse gases into the atmosphere and raising the temperature. Over many years, the Martian atmosphere would become oxygenated to the point that humans would need only a breathing-assistance apparatus but not the pressure suits currently worn by astronauts.
    - To observe how this might work, have students create their own greenhouse gas factories using two soda bottles (directions can be found here: http://tlc.howstuffworks.com/family/plant-activities-for-kids4.htm). Students should plant small plants in one of the terrariums and place no plants in the other terrarium. The terrariums should be placed in the same amount of sunlight.
    - Students should place a thermometer inside of each terrarium and place a third thermometer in a location that gets the same sunlight; the third thermometer should not be in a bottle.
    - Have students measure the temperature on all three thermometers when they are first placed in the bottles and then record the temperatures on all three thermometers in ten minute increments over the course of two hours.
    - When done, have students create a 3-line line graph, with each line a different color, representing the temperatures on the three thermometers.
    - Students should compare what happened to the temperature on all three thermometers. Students should notice that the temperature in the terrarium with plants rose significantly higher than the temperature on the other two thermometers.

- Discuss what the experiment illustrates in terms of the relationship between greenhouse gases and temperatures. Ask students to reflect on how this applies to Earth and Mars.
- To learn more about terraforming of Mars, including additional proposed ideas, students can read the following articles:
  - http://science.howstuffworks.com/terraforming1.htm
  - http://www.quest.nasa.gov/mars/background/terra.html
  - http://www.astrobio.net/interview/1074/terraforming-mars-the-noble-experiment