STEM Careers Coalition

CLASSROOM ACTIVITY

Fabricating our Future

OBJECTIVES

Students will be able to:

- **Investigate** how a 3D printer works
- **Define** the criteria and constraints of creating a habitable community on Mars
- **Create** a two-dimensional habitat design for additive manufacturing that addresses a deep space challenge
- **Assess** another 3D printing design and integrate the design ideas of their peers in order to optimize their own design

OVERARCHING QUESTION

How can additive manufacturing expand the horizons of human exploration?

ACTIVITY SUMMARY

Students will investigate the applications of 3D printing in deep space. They will explore the challenges that are associated with a Martian habitat and they will develop a design for additive manufacturing that considers these obstacles and helps humans live on Mars.

MATERIALS

- 3D Printing in 30 Seconds video, to project
- Designing Solutions Handout, one per student
- The Human Body in Space article, enough for half the class
- Devices with internet access, at least enough for one-quarter of the class
- Copy paper, enough for about one-quarter of the class

CHALLENGE

1. Partner Brainstorm: Divide the class into pairs and instruct each pair to label a piece of paper from #1–10. Then pose the following question: Based on construction you have observed in the world around you, what are some steps that go into constructing a building or home?

   On the board, write "#1: Architectural plans approved" and "#10: Construction complete!" Then give pairs a few minutes to brainstorm some of the steps that may occur in between.

2. Next, show students the 3D Printing in 30 Seconds video and explain prior to viewing that the video will demonstrate another type of construction. When the video is complete, lead the class in comparing and contrasting the differences between what was seen in the video and the building construction process that they previously considered.

3. Conclude the discussion by explaining that "regular" construction uses what is called a *subtractive process*, meaning that it begins with materials that are larger than needed and then cuts them to make them smaller. 3D printing, on the other hand, is referred to as additive manufacturing because it begins with nothing and deposits material one layer at a time. 3D printing design is based on a digital file and adds material only exactly where it is needed.

4. Ask students to think-pair-share* their thoughts on the following: additive and subtractive manufacturing both have pros and cons. If you were planning to create a structure in outer space, which type of manufacturing may make more sense? Why?

   *In a think-pair-share, students think about the question independently, discuss their answers with a partner, and then share their thoughts with the larger class.

5. Explain that NASA and companies that focus on space exploration are investing in 3D printing because it may enable them to construct space habitats without having to transport materials! In fact, scientists and engineers are currently working on space-based robots that could 3D-print using cement in order to build simple buildings and other structures. Robots with this 3D printing functionality could create a basic habitat on Mars before humans arrive.

6. Tell students that today they are going to pretend to be deep space civil engineers. Explain that civil engineers are responsible for planning, designing, and overseeing the construction of community buildings and systems—so as deep space civil engineers, students will help create Martian infrastructure!

   Elaborate and explain that more specifically, students will create a design for 3D printing that a robot could use as it begins to construct a human habitat on Mars. Remind students of the enormity of this project. Mars is a planet with many environmental challenges on which no man or woman has yet to step foot!

7. Distribute one Designing Solutions Handout to each student, and then elaborate on the challenge by reading aloud the bullets listed under *Step 1: Define the Challenge*. Explain that students will complete this challenge in groups of four.

8. After answering questions, prepare student groups to perform research to better understand the challenge:

   - Distribute two copies of the "The Human Body in Space" article to each group and explain that this article details some of the obstacles associated with human life in deep space
   - Write the following website on the board and explain that this website contains background information about Mars as well as details about some of the challenges that Mars presents

     Website: solarsystem.nasa.gov/planets/mars
   - Explain that student groups will have about 15 minutes to perform research. At the end of the research period, each group should have a better idea of challenges that humans would face in a Martian habitat. Encourage groups to divide the research responsibilities (e.g. two students can begin reading the article and two students can use devices to begin the internet research). Remind students to only take notes on information that may be relevant to challenges that humans may face on Mars

DESIGN

1. Bring the class back together and explain that it's now time to develop a solution to the challenge. Call on a student to read the handout's *Step 2: Create a Design* section aloud.
2. Tell the class that they will have about 15 minutes to create a design for a Martian habitat structure that mitigates two of the planet's challenges. Encourage students to think outside the box: While homes will certainly be needed on Mars, groups can also consider other aspects of a community such as an indoor garden space, a gym, covered walkways, roads, etc.
3. Quickly recap and encourage students to:
    - Use their research notes to create a design for a Martian habitat structure that overcomes two of its planetary challenges
    - Use a separate piece of paper to sketch a draft of their proposed design
    - Be ready to explain and justify the rationale behind their design solution

SOLVE

1. When there are about 15 minutes left in the class period, pair every group with another group. Explain that each group will share their design with each other. As they do, they must:
    - Share the Martian challenges that they identified and how their design overcomes these obstacles
    - Listen carefully to the other team's explanation, and ask questions rooted in the research they performed
    - Discuss how both groups' design ideas could be combined to create a larger Martian habitat
2. Go on to explain that once both designs have been shared, each group should complete the *Step 3: Analyze Solutions* portion of the handout which will probe them to optimize their designs and incorporate the ideas of their peers. If time permits, they may edit or redraw their design in order to illustrate these optimizations. Remember that the ultimate goal of the solution is to create a deep space habit that will sustain human life.

OPTIONAL EXTENSIONS

1. Students can use 3D design software to turn their sketch into a 3D printer-ready design.
2. Students can use modeling clay to simulate additive manufacturing and create a 3D model of their deep space habitat.

STANDARDS

Next Generation Science Standards

- Space Systems
    - Crosscutting Concept—Interdependence of Science, Engineering, and Technology: Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems. (MS-ESS1-3)
- Engineering Design
    - MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
    - Crosscutting Concept—Influence of Science, Engineering, and Technology on Society and the Natural World: The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)
    - Disciplinary Core Idea—ETS1.B: Developing Possible Solutions: Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)

ITEEA Technological Literacy Standards

- Standard 1: Students will develop an understanding of the characteristics and scope of technology. In order to comprehend the scope of technology, students should learn that:
    - F. New products and systems can be developed to solve problems or to help do things that could not be done without technology.
    - H. Technology is closely linked to creativity, which has resulted in innovation.
- Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study. In order to appreciate the relationships among technologies, as well as with other fields of study, students should learn that:
    - E. A product, system, or environment developed for one setting may be applied to another setting.
- Standard 9: Students will develop an understanding of engineering design. In order to comprehend engineering design, students should learn that:
    - H. Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.
- Standard 11: Students will develop abilities to apply the design process. As part of learning how to apply design processes, students should be able to:
    - H. Apply a design process to solve problems in and beyond the laboratory-classroom.
    - I. Specify criteria and constraints for the design.
    - J. Make two-dimensional and three-dimensional representations of the designed solution.
- Standard 20: Students will develop an understanding of and be able to select and use construction technologies. In order to select, use, and understand construction technologies, students should learn that:
    - F. The selection of designs for structures is based on factors such as building laws and codes, style, convenience, cost, climate, and function.

DESIGNING SOLUTIONS

STEP 1: DEFINE THE CHALLENGE

Your deep space civil engineering challenge is to:

1. Research and identify two of the challenges associated with living on Mars.
2. Consider the design elements a Martian habitat would need in order to overcome these challenges.
3. Design a structure that a robot could create on Mars using 3D printing.

List brainstorming and research notes that could help you tackle the challenge:

STEP 2: CREATE A DESIGN

3D printing begins with 2D design. Work with your group to select two Martian challenges on which to focus, and brainstorm how a Mars habitat could be constructed in a way that addresses these obstacles. Then apply your research *and* your creativity to create a design of a structure that could be part of a Martian habitat!

Use the space below to brainstorm, and then work as a team to draw a model on a separate piece of paper.

STEP 3: ANALYZE SOLUTIONS

Consider how to improve your habitat design by incorporating your peers' ideas. Then work as a group to describe below at least two ways to enhance your original design and create a larger community space: