FLINN STEM

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IMSA Fusion—Mars STEM Curriculum Module

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Curricular Objectives

Students completing this curriculum will understand that:

- Mars is a hostile environment. Although conditions there are quite different from Earth, both landscapes were shaped by many of the same physical processes. Certain unique features of Mars, however, are being studied closely. Citizen scientists can make a contribution to this effort.
- Designing a manned mission to Mars will be one of the greatest technical challenges ever undertaken by mankind. Yet, the challenge is largely one of complexity and cost. There are no hurdles which are beyond current scientific understanding.
- The ultimate goal of establishing a permanent colony on Mars will depend on finding ways to utilize Martian resources to attain complete self-sufficiency.

Students will arrive at these understandings through hands-on scientific inquiry. As they explore the content, students will gain valuable experience with the practices identified in the Common Core mathematics standards as well as the Next Generation Science Standards.

Logistics

Students: 30 students in grades 6 – 8

Location: Activities are suitable for standard classrooms if laptop carts are available. Otherwise, some visits to a computer lab will be required.

Time: This curriculum contains approximately 32 content hours. Times for individual activities are typically 1 to 2 hours and detailed estimates are found at the beginning of each activity.

Introduction

From the earliest days of space exploration, no other object has excited the imagination of writers, scientists, engineers, and the public more than Mars. A neighbor in space, and visible to the naked eye on many clear evenings, the Red Planet beckons.

The development of modern rocketry was advanced by visionaries such as Robert Goddard and Werner von Braun, who always considered Mars to be their true destination. Today, we have the technology to make that dream a reality. What's more, there is a compelling reason to go, beyond the human instinct for exploration. Life on Earth has suffered a series of extinction events over its long history and there is no reason to expect the future to be uneventful. Becoming a multi-planetary species is the surest means of securing a long and prosperous future for humanity.

MARS: MANIFEST DESTINY

If Mars proves to be without native life, as seems likely given our current understanding, then human colonists will one day become "the Martians". There is, however, another possibility. Although no evidence for life of Mars has yet been discovered, much research in this area continues. If native life, even microscopic, is discovered on Mars, then the moral equation changes completely. Past campaigns of colonization in the name of Manifest Destiny have had catastrophic results for native populations in the Americas and elsewhere. What would it mean for life on Mars? Could humans colonize Mars without driving the native ecology to extinction?

Such questions cannot be answered without a more complete understanding of the Red Planet. Humans may go to Mars in the 2030's, as currently planned. Most likely, they will find no Martian organisms to worry about. Even if they should, and governments decide against colonization, the discovery and in-situ study of Martian organisms would be the most astounding achievement of the century. There is no reason not to begin planning the first manned mission to Mars immediately. Your students begin today!

National Standards

Next Generation Science Standards:

MS-ESS1-2: *Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.*
MS-ESS1-3: *Analyze and interpret data to determine scale properties of objects in the solar system.*
MS-ESS3-3*: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*
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.*
MS-ETS1-2: *Evaluate competing design solutions using a systemic process to determine how well they meet the criteria and constraints of the problem.*
MS-ETS1-3: *Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.*
MS-ETS1-4: *Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.*
MS-PS2-2: *Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.*
MS-PS3-3: *Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*

NGSS Science and Engineering Practices:

SEP1: *Asking questions and defining problems*
SEP2: *Developing and using models*
SEP3: *Planning and carrying out investigations*
SEP4: *Analyzing and interpreting data*
SEP5: *Using mathematics and computational thinking*
SEP6: *Constructing explanations and designing solutions*
SEP7: *Engaging in argument from evidence*
SEP8: *Obtaining, evaluating, and communicating information*

Next Generation Science Standards Reference:

NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press.

Mathematics Common Core Standards:

CCSS.Math.Content.6.EE.B.6 *Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.*

CCSS.Math.Content.6.EE.B.7 *Solve real-world and mathematical problems by writing and solving equations of the form x + p = q and px = q for cases in which p, q and x are all nonnegative rational numbers.*
CCSS.Math.Content.6.NS.C.8 *Solve real world and mathematical problems by graphing points in all four quadrants of the coordinate plane***.**
CCSS.Math.Content.6.RP.A.2 *Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship.*
CCSS.Math.Content.6.RP.A.3 *Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.*
CCSS.Math.Content.6.G.A.2 *Find the volume of a right rectangular prism with fractional edge lengths by packing it with unit cubes of the appropriate unit fraction edge lengths, and show that the volume is the same as would be found by multiplying the edge lengths of the prism. Apply the formulas V = l w h and V = b h to find volumes of right rectangular prisms with fractional edge lengths in the context of solving real-world and mathematical problems.*
CCSS.Math.Content.6.G.A.4 *Represent three-dimensional figures using nets made up of rectangles and triangles, and use the nets to find the surface area of these figures. Apply these techniques in the context of solving real-world and mathematical problems.*
CCSS.Math.Content.7.G.A.1 *Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.*
CCSS.Math.Content.7.G.B.4 *Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between the circumference and area of a circle.*
CCSS.Math.Content.7.G.B.6 *Solve real-world and mathematical problems involving area, volume and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.*
CCSS.Math.Content.7.RP.A.2 *Recognize and represent proportional relationships between quantities.*
CCSS.Math.Content.8.EE.A.2 *Use square root and cube root symbols to represent solutions to equations of the form $x^2 = p$ and $x^3 = p$, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that √2 is irrational.*
CCSS.Math.Content.8.G.C.9 *Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems.*

<u>Mathematical Practices</u>:
CCSS.Math.Practice.MP1: *Make sense of problems and persevere in solving them*
CCSS.Math.Practice.MP2: *Reason abstractly and quantitatively*
CCSS.Math.Practice.MP3: *Construct viable arguments and critique the reasoning of others*
CCSS.Math.Practice.MP4: *Model with mathematics*
CCSS.Math.Practice.MP5: *Use appropriate tools strategically*

CCSS.Math.Practice.MP6: *Attend to precision*
CCSS.Math.Practice.MP7: *Look for and make use of structure*
CCSS.Math.Practice.MP8: *Look for and express regularity in repeated reasoning*

Common Core English Language Arts (ELA) Standards:
6-8.RI.7: *Evaluate the advantages and disadvantages of using different mediums to present a particular topic or idea.*
6-8.SL.1: *Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on middle school topics, texts, and issues, building on others' ideas and expressing their own clearly.*
6-8.SL.2: *Analyze the purpose of information presented in diverse media and formats and evaluate the motives behind its presentation.*
6-8.SL.3: *Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and relevance and sufficiency of the evidence and identifying when irrelevant evidence is introduced.*
6-8.SL.5: *Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.*
6-8.RST.3: *Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.*
6-8.RST.4: *Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context.*
6-8.W.1: *Write arguments to support claims with clear reasons and relevant evidence*
6-8.W.2: *Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content*
6.W.3: *Write narratives to develop real or imagined experiences or events using effective technique, relevant details and well-structured event sequences.*
6-8.WHST.1: *Write arguments based on discipline-specific content.*

Common Core Mathematics and ELA Standards Reference
Authors: National Governors Association Center for Best Practices, Council of Chief State School Officers Title: Common Core State Standards Publisher: National Governors Association Center for Best Practices, Council of Chief State School Officers, Washington D.C. Copyright Date: 2010

Unit Summaries and Planning

Unit 1 – Spacefaring or Extinct 

This unit introduces the problem-centered challenge of designing the first manned mission to Mars. The first activity activates prior knowledge and allows students to play a board game. The game introduces many of the social and ethical issues involved in sending humans to Mars, as well as the hazards those astronauts will face. Student groups will then create infographics depicting their views on "What should a person know about travelling to Mars?"

Unit 2 – Environmental Conditions 

Students compare the environments and landscapes of Earth and Mars. Using actual data from spacecraft orbiting Mars, students will construct multi-layer maps of the for the purpose of selecting the most advantageous landing site for their mission. Using an online tool called *Mars Trek*, students can virtually explore their chosen landing site as well as other interesting features on the surface of the Red Planet.

Unit 3 – Citizen Science 

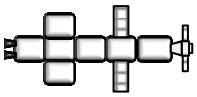
Students will study photographs of interesting features on the south polar ice caps. Using materials to simulate Martian soil and ice, students will conduct experiments in an effort to model the observed features. Finally, they will use an online website to classify the features as part of an ongoing research project called *Planet Four*, involving citizen scientists across the globe.

Unit 4 – Orbital Mechanics 

This unit addresses some of the misconceptions students are likely to have about space travel. They will study elliptical orbits and learn how to shift from one orbit to another using the least possible amount of energy and fuel. Finally, they will chart a transfer orbit to Mars and calculate the critical factors which will drive the subsequent design of their spacecraft.

Unit 5 – To Boldly Go 

Students begin by observing a video of a rocket launch before using a set of materials to test an idea they have about how a multi-stage rocket works. They will learn the role of the Space Launch System in getting heavy payloads into orbit. As they continue planning their first mission to Mars, students will determine how many astronauts are needed as well as the mass and volume of consumable supplies which those astronauts will need to complete the mission objectives selected by the class.

Unit 6 – Mars Transit Vehicle 

In this unit, students will design a Mars Transit Vehicle capable of taking their crew to Mars and returning them safely to Earth. Using realistic design constraints and decisions made in previous units, students will calculate everything from the size of the storage lockers to the size of solar panels and thermal radiators. As they design, they will assemble a 1/100 scale prototype of their vehicle.

Unit 7 – Mission Architecture 

Students will learn to construct Gantt charts and apply this knowledge to plan their mission. Once they have their plan charted, it will be used to help them make rapid decisions in the face of unexpected system failures. Go or abort? Students must decide.

Unit 8 – Ice Truckers 

Students will consider the requirements for a Martian cargo rover. After seeing examples of other rovers, students will design, build, and test a prototype of their own. The emphasis will be on communications and cooperation between small teams as students are introduced to the concept of Systems Engineering.

Unit 9 – We Are the Martians 

Students will consider the practical difficulties of constructing a permanent colony on Mars. First, they will experiment with construction techniques and materials by building and testing domes of simulated Martian concrete. Next, they will examine what it means for a community to be self-sufficient by looking at their own communities on Earth. Finally, they will design the physical layout of a colony for 500 Martian settlers.

Strategies for Planning your Fusion Program

If a Fusion program has less than 32 instructional hours available, then teachers will need to make thoughtful decisions about which units to use and which to skip. The following chart may be helpful if choosing units by theme.

Units	Theme	Instructional Time
1 - 3	Mars, the planet	11 hours
4 - 7	Spaceflight, the first mission	16 hours
8 - 9	Living on Mars, the permanent colony	7 hours

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Objectives:

- Explore, support and challenge the technical, physiological, social and ethical issues around human space exploration.
- Evaluate the risks and rewards of spacefaring, and discuss why a manned mission to Mars is, or is not, appropriate for the human species.
- Determine motivation for, or against, traveling to Mars and justify this decision with information and logic.
- Gather information about the Red Planet, including average temperature patterns, atmospheric conditions, distance from the sun, and other factors that ultimately influence space travel design and preparation.

Background Information

Humans have dreamed of traveling into space for many years. The pursuit of exploring beyond our Earth has been persistent and enduring. Since the beginning of the 20th Century, space programs have worked diligently to develop the technology and information systems necessary to send explorers into space. Consequently forming a market of competition among participating countries (i.e, China, Germany, Russia and the United States), the desire to explore space initiated the engineering of rockets, and later, plans to send humans into space.

The United States, an active and accomplished contributor to space travel, successfully sent its first satellite, Explorer 1, into orbit on January 31, 1958. Several years later, in 1961, the U.S.'s Alan Shepard became the first American to fly into space. Continuing to send men into space, on February 20, 1962, John Glenn became the first American to reach Earth's orbit. Finally, on July 20, 1969, with sights on exploring new planets in our solar system, Neil Armstrong took "a giant step for mankind" as he stepped onto the Moon (source: Aerospace). Now, with increased attention on furthering our exploration to other planets, developing a detailed plan to complete the first manned mission to Mars is being pursued.

The first images of Mars were taken by the Mariner 4, a fly-by spacecraft sent into orbit in 1965. Since then, while dozens of orbiters, landers and rovers have been launched into space to study the Red Planet, only about one of every three missions has been a success. Yet, information and data received from these

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successful missions have provided an interesting insight into the topography, atmosphere, weather and geology of a planet yet to be explored by humans.

In 2016, President Barack Obama set a clear goal to send humans to Mars by the 2030s. President Donald Trump has also echoed the urgency of achieving this task. Currently, commercial partners are working to build new habitats that can sustain and transport astronauts on long-duration missions in deep space. These missions will teach us how humans can live far from Earth.

There are many documented and published reasons for sending humans to Mars. These include discovering information about Mars that cannot be achieved by robots, inspiring current and future scientists, building morale and prosperity for the United States, the growth of diplomacy, and arguably the most significant, the advancement and expansion of humanity.

Elon Musk, the CEO and founder of Tesla and SpaceX, explains the need for humans to expand past this planet (source: Nu Sci):

> I really think there's a fundamental difference, if you sort of look into the future, between a humanity that is a spacefaring civilization, that's out there exploring the stars, on multiple planets, and I think that's really exciting, compared with one where we are forever confined to Earth until some eventual extinction event.

While significant achievements have been made in planning and preparing for the first manned mission to Mars, educating the public about the risks and rewards of space travel is important. Information gained from space explorations provide an abundance of new ideas and ground-breaking technologies that are used in our day-to-day living.

Infographics, a resource growing in popularity, are often used to simplify a complicated or mundane subject into an interesting and attractive visual. A tool to educate and inform, infographics integrate words and graphics to reveal information, patterns or trends. Created with the understanding that humans receive input from all five sense, but significantly more information through vision, infographics balance visual content (colors, theme) with content (data, information) and knowledge (insight into the content).

Inquiry Overview

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In the following activity, students will be presented with a Request for Information which will set the stage for studying and planning a Mars mission to launch in 2033. After brainstorming a list of known characteristics about Mars, students will participate in Mars: Manifest Destiny, a board game designed to introduce basic information about the Red Planet while introducing several technical, social and ethical issues which surround space travel. Students will work collaboratively to share thoughts regarding the risks and rewards of traveling to Mars while summarizing the implications of this task.

Next, students will reflect on their knowledge of space travel, Mars, and information gained from the board game to evaluate three questions:

- **Should we, as a human species, go to Mars?**
- **Should we, the United States, go to Mars?**
- **Would you go to Mars?**

Then, after viewing a series of infographics, students will work with a partner to design their own infographic that answers the question, "What should a person know about traveling to Mars?" This visual resource will demonstrate a balance of informational content and images, and will be shared with the class as a tool to present complex information quickly and clearly.

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Activities

Activity 1: Mars: Manifest Destiny

Objectives:

- Explore, support and challenge the technical, physiological, social and ethical issues around human space exploration.
- Gather information about the Red Planet, including average temperature patterns, atmospheric conditions, distance from the sun, and other factors that ultimately influence space travel design and preparation.

Standards:

CCSS ELA/Literacy: 6.RI.7, 6-8.W.2, 6-8.SL.1

***Estimated Time* (60 minutes total):**

- **15 Minutes – Presentation of Letter**
- **35 Minutes – Board Game**
- **10 Minutes – Debrief**

Materials:

for each student:

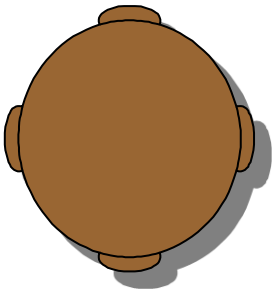
- *Student Pages*

for each team of four:

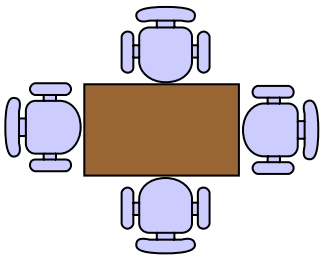
- 1 Mars: Manifest Destiny Game Board
- 1 Die
- 1 set of Game Cards
- 4 Playing Pawns (four separate colors)

for the teacher:

- Game Directions PowerPoint
- Request for Information PowerPoint
- 1 piece of Chart Paper
- 1 Chart Marker



Seating Arrangement



Suggested Inquiry Approach:

Arrange students in groups of four. It is important that students are seated around a circular or rectangular table so they are directly across from one another. Please rearrange the classroom, if necessary.

Begin by displaying the Request for Information PowerPoint. This document can be located in the Teacher Resources file of this unit in the Content Classroom at learning.imsa.edu.

Allow several minutes for students to read the document. Then, pose the following questions to the whole class and select individual students to share their thoughts:

- **Why do you think people are so interested in traveling to Mars?**
- **The letter says that you will "study a Mars mission to be launched in 2033." What do you think is involved in planning a space mission?**

- **How old will you be in 2033?**

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Then, ask students:

- **What do you know about Mars?**

As students share their ideas, record their thoughts on the provided chart paper. It is suggested that this visual remains in a location within the classroom to reference throughout the entirety of this curriculum. This record serves as evidence of students' prior knowledge and will evolve as they experience new learning opportunities and challenges.

Next, distribute student pages, the Mars: Manifest Destiny Game Board, number die, game cards and four playing pawns. Refer to the directions as provided on the student pages. A PowerPoint slide is also available to display for the students. This can be found in the Teacher Resources file of the Content Classroom at learning.imsa.edu. Take several minutes to answer any questions that students may have about playing the game. Allow 30-40 minutes for students to complete the game. Once each team has finished, they should discuss and answer the reflection questions on their student pages.

Debrief Activity 1:

Following completion of the game, ask students to talk among their teams and summarize the information they learned while playing the game. Suggested questions for discussion include:

- ***What information presented in the game surprised you the most? Why?***
- ***Why do you believe people are so interested in going to Mars?***
- ***What do you think would be the first step in preparing to travel to Mars? Why do you think this?***
- ***Who do you think is involved in planning a manned mission to Mars? What is their role?***
- ***What do you think the title of the game,* Mars: Manifest Destiny, *means?***

Students may wish to return to the game at any time throughout the curriculum.

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Activity 2: Visualizing the Information

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Objectives:

- Explore, support and challenge the technical, physiological, social and ethical issues around human space exploration.
- Evaluate the risks and rewards of spacefaring, and discuss why a manned mission to Mars is, or is not, appropriate for the human species.
- Determine motivation for, or against, traveling to Mars and justify this decision with information and logic.

Standards:

CCSS ELA/Literacy: 6-8.W.2, 6-8.SL.1, 6-8.SL.5

***Estimated Time* (90 minutes total):**

- **15 Minutes – Introduction**
- **45 Minutes – Infographic Design**
- **15 Minutes – Share and Debrief**

Materials:

for each student:

- *Student Pages*

for each group of two:

- 9”x12” Colored Construction Paper
- 12”x18” White Construction Paper
- 9”x12” Neon Construction Paper
- 1 pack of Colored Markers (to be shared)
- 1 set of Game Cards from Activity 1
- *Computer with Internet Access (optional)*

for the teacher:

- Infographics PowerPoint

Suggested Inquiry Approach:

Students will begin this activity by reforming the small groups from Activity 1. Each group should be provided with the appropriate student pages and game cards from the *Mars: Manifest Destiny* board game.

Select one volunteer to read the Background Information aloud. Then, provide several minutes for the students to read and discuss the three focus questions:

- **Should we, as a human species, go to Mars?**
- **Should we, the United States, go to Mars?**
- **Would you go to Mars?**

To answer these questions, students may refer to the information provided on the game cards, in addition to prior knowledge and insights gained from their peers, to provide a rationale for their answers. Students should record their responses and opinions in the provided space on the student pages. Encourage students to justify their reasoning with appropriate information.

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Once all small groups have completed their work, allow students to share their thoughts as a whole class. During this conversation, reiterate to students that there is no one, correct answer to the preceding questions. When discussing social and ethical issues, all ideas and thoughts are to be respected and welcome.

The Content Classroom can be located at imsa.learning.edu

At this time, display the Infographics PowerPoint, located in the Teacher Resource folder of the Content Classroom for this unit. Explain to the students that infographics are visual representations that are used to share information. Students will use this resource to present information that would be important for a person to know if they were to consider traveling to Mars.

For each infographic included in the PowerPoint, allow students to discuss the information or data illustrated and make simple observations about how the visual content is displayed. At the end of the PowerPoint, pose the following questions to the whole class:

- **What do you notice about the information presented in the infographics?**
- **What do you notice about the visual characteristics of the infographics, such as the colors, shapes, amount of content on the page, etc.?**
- **How long did it take you to understand the "message" of each infographic?**

Inform students that they will now create an infographic to organize and display information that would be useful to someone that is considering traveling to Mars.

After dividing each small group into partner teams, students should sort the *Mars: Manifest Destiny* game cards into two piles according to color: blue and yellow. Each partner team should then take a pile of cards. Information presented on the cards may be used as content for the infographic.

Students may also refer to their own knowledge of Mars and space exploration to construct their infographic. Alternatively, students could further investigate a facet of traveling to Mars by completing their own research.

<u>Note:</u> If resources allow, students may also create their infographic online using design software such as Piktochart. This website requires students to login with a pre-established email address. Once an infographic has been completed,

students may share or print their document.

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Once students have completed their infographic, allow several minutes for volunteers to share their image with the class. Encourage students to elaborate on the information they chose to represent and how they constructed their graphics. Once each partner team has presented their visual, reconvene for a whole class debriefing session.

Debriefing Activity 2:

- ***What do you believe are the most significant rewards of completing a manned mission to Mars?***
- ***What do you believe are the most significant risks of attempting a manned mission to Mars?***
- ***Why do you believe people are so interested in space travel?***
- ***On October 4, 1957, the Soviets launched the first artificial satellite, Sputnik 1, into space. Since then, hundreds of astronauts, rockets, rovers and satellites have been sent into space. How do you think space exploration has benefited our population?***

Extension

Students may choose to display their infographics outside of the classroom to provide classmates outside of IMSA Fusion with information about traveling to Mars. This would also provide students an opportunity to ask the question, "Would You Go to Mars?" and poll classmates during the regular school day. Students may also choose to ask, "Why or why not?" to survey explanations in response to their initial question. IMSA Fusion students could then use this information to predict what aspects of traveling to Mars are attractive, or worrisome, to their peers.

Prepare an area for students to exhibit this information. A bulletin board or whiteboard is recommended.

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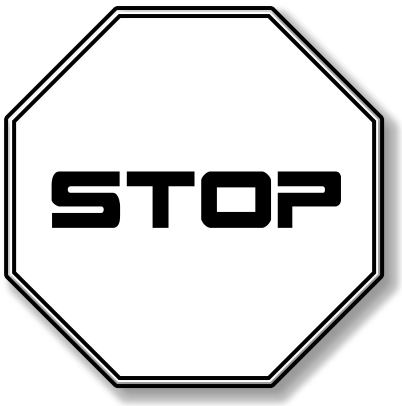

Before moving on to the next unit, be sure to submit your feedback to the Content Classroom at https://learning.imsa.edu/

Mars: Manifest Destiny

Request for Information:
From the office of Professional Field Services of the Illinois Mathematics and Science Academy

On March 21st, 2017, President Trump signed into law bill S.422, the NASA Transition Authorization Act of 2017. In this law, NASA is directed to contract with an independent organization to study a Mars mission to be launched in 2033.

The Illinois Mathematics and Science Academy (IMSA) plans to be the organization which develops that study for NASA.

By reaching out to Fusion students for ideas, IMSA can directly involve the very generation which will be building the spacecraft and making the voyage of exploration to Mars.

The scientists, engineers, managers, and astronauts who conquer Mars in 2033 are currently students in elementary and middle schools. Who else could be as motivated to take on this challenge?

Your IMSA Fusion class has been selected to participate. Your ideas are needed. Help us fulfil our destiny to be a nation of explorers and a spacefaring species.

Dr. Norman "Storm" Robinson III
Executive Director, Professional Field Services
Illinois Mathematics and Science Academy

Background Information: In the 19th Century, **manifest destiny** was the belief that the United States was destined to stretch from coast to coast, across North America. During this time, the American people viewed it as their virtue, mission and destiny to expand their society. In his 1776 pamphlet, *Common Sense*, Thomas Paine explained this opportunity, stating, "We have it in our power to begin the world over again. A situation, similar to the present, hath not happened since the days of Noah until now. The birthday of a new world is at hand…" Today, with an eye on Mars and plans to complete the first manned mission to the Red Planet, many have stated that our new destiny is to look beyond our Earth for resources to sustain mankind. Mars, a **terrestrial** planet considered Earth's analog in terms of hospitable environments, may serve as an option. However, the rewards of space travel, or **spacefaring**, do not come without risk.

Questions of Interest:

- Why do people want to go to Mars?
- What are the risks and rewards of completing a manned mission to Mars?

Materials:

- **1 Mars: Manifest Destiny Game Board**
- **1 set of Game Cards**
- **4 Playing Pawns (of different colors)**
- **1 Die**

Aim of the Game:

Be the first player to travel from Earth to Mars. Along the way, you will encounter obstacles and achievements as you experience the rewards of space exploration and the risks of the mission.

Preparation:

Begin by selecting a playing pawn and shuffling the deck of game cards. Position the game board so all players can easily move their pawns from circle to circle. Set up the game board placing each player's pawn on EARTH and the game cards in the rectangle labeled DRAW. Place the number die on the game board.

How to Play:

Each player will roll the die. The player that rolls the highest number will begin as *Player 1*. Play will continue in a **clockwise** manner (unless instructed otherwise!) for each player turn.

When it is your turn, roll the die and move your pawn, circle by circle, the number shown on the die. If at any time you can move, you must move, even if it's to your disadvantage. Two or more pawns may be on the same space at the same time.

If you land on  **,** draw a game card. Read the information on the card aloud and follow the instructions as written. If you are instructed to exchange game piece locations with an opponent but do not wish to do so, you may forfeit your move. After completing the instruction on the game card, place the card in the DISCARD pile. If all game cards in the DRAW pile have been used before the end of the game, shuffle the cards in the DISCARD pile and replace them back in the rectangle labeled DRAW. Continue play.

Winning the Game:

The first player to reach Mars wins the game. You must land there by exact count. If your roll would take you past Mars, you cannot move. Try again on your next turn.

Discuss:

- **What information present in the game surprised you the most?**

- **Why do you believe people are so interested in going to Mars?**

- **What do you think would be the first step in preparing to travel to Mars?**

- **What are the risks of traveling to Mars? What are the rewards?**

Background Information: While significant achievements have been made in planning and preparing for the first manned mission to Mars, educating the public about the risks and rewards of space travel is important. Historically, the idea of space exploration has excited and intrigued many people. However, for some, the risks of this feat outweigh the rewards. In the following activity, you will create an **infographic** to illustrate valuable information that people should know about traveling to Mars.

Headline: What should a person know about traveling to Mars?

Materials:

- **1 set of Mars: Manifest Destiny Game Cards**
- **Construction Paper**
- **Colored Markers**

Procedure:

1. Reflecting on your knowledge of space travel, Mars, and information you gained from playing *Mars: Manifest Destiny*, answer the following questions. Justify your reasoning.

Should we, as a human species, go to Mars?	Should we, the United States, go to Mars?	Would you go to Mars?

2. Take several minutes to view the Infographics PowerPoint with your instructor. In the space below, record any observations you notice about the information presented and visual characteristics of each infographic.

3. Working together, separate the *Mars: Manifest Destiny* game cards into two colors according to color (blue or yellow). Then, divide your small group into two partner teams. Each partner team will take one color.

4. You and your partner will now design an infographic, complete with content and visual images, to answer the question "**What should a person know about traveling to Mars?**"

5. Using the information written on the game cards, or your own knowledge of space travel and Mars, record data and information that you will include in your infographic. You may also make notes of any images, color schemes, symbols, or other characteristics that you will use to make your infographic: