**Mars Farm**

**Grade level(s):** 6-8 **Subject(s):** Science

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**Problem Statement:**

As part of a long term strategy to sustain the human race, NASA is exploring the feasibility of sustainable living on another planet. It is planning to send a team of three researchers to Mars for three years to study Martian living as a proof of concept.

The orbits of Mars and Earth position the two planets closest to each other once every two years. This is the optimal time to send a spacecraft. The journey will take just less than a year, about 300 days. The spacecraft, called Mars One, has already been designed and is currently being built. It has provisions to sustain three passengers for the journey plus one year after they arrive.  The vessel will continue to function as a shelter, housing the three researchers and providing power, air, and water for a three-year period.

The harsh conditions on the planet will require the researchers to supply their own food within a controlled environment for the remaining two years. NASA needs to find out how large of a controlled environment is needed. They have hired your team to analyze the requirements and submit a report in the form of a proposal.

An analysis of the Martian soil sent back to earth by the Mars Rover indicates it is compatible with Earth soil and will provide the nutrients required to grow any plants that would normally grow on Earth. Your proposal should account for nutritional needs at 3,000 calories per day. In addition to energy needs, your team should also consider taste variety in your proposal. A separate team is developing special nutrition bars to provide additional energy requirements to keep the researchers healthy.

Your completed proposal should include the following elements:

* A selection of plants that provide the needed calories while minimizing water use, take up the least amount of space, and can grow fast enough to provide a sustainable yield before rations run out.
* A scaled drawing and/or model of the agricultural layout that allows researchers to access each crop for proper care and harvesting.

**Conceptual Storyline:**

**Unit Standards (NGSS, CCSS, CTE):**

NGSS practices addressed in unit

Asking Questions and Defining Problems

* defining system boundaries
* defining components of the process
* identifying embedded systems
* identifying societal/personal needs relative to the problem
* define criteria and constraints

Developing and Using Models

* define and label essential variables of model
* describe relationships of components
* connect model to casual phenomena

Planning and Carrying Out Investigations

* identify the phenomenon investigated
* evaluate the accuracy of the data presented
* refine the investigation to produce more accurate data

Analyzing and Interpreting Data

* analyze models using appropriate tools
* interpret patterns in data

Using Mathematical and Computational Thinking

* use mathematical representations to describe relationships
* analyze representations to support claims

Constructing Explanations and Designing Solutions

* articulate an explanation
* cite evidence to support explanation
* describe connected reasoning
* evaluate potential solutions

Engaging in Argument from Evidence

* evaluate claims and reasoning
* identify additional evidence
* evaluate the logic of given reasoning

Obtaining, Evaluating and Communicating Information

* communicate information in at least 2 different formats
* use clear and effective communication skills
* connect DCI and CCC

#### [CCSS.Math.Practice.MP1](http://www.corestandards.org/Math/Practice/MP1/)

#### Make sense of problems and persevere in solving them.

#### [CCSS.Math.Practice.MP4](http://www.corestandards.org/Math/Practice/MP4/)

#### Model with mathematics.

#### [CCSS.Math.Practice.MP5](http://www.corestandards.org/Math/Practice/MP5/)

#### Use appropriate tools strategically.

#### [CSS.Math.Practice.MP6](http://www.corestandards.org/Math/Practice/MP6/)

#### Attend to precision.

#### [CCSS.Math.Content.6.RP.A.1](http://www.corestandards.org/Math/Content/6/RP/A/1/)

#### Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

[CSS.Math.Content.6.RP.A.3](http://www.corestandards.org/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.1](http://www.corestandards.org/Math/Content/6/G/A/1/)

Find the area of right triangles, other triangles, special quadrilaterals, and polygons by composing into rectangles or decomposing into triangles and other shapes; apply these techniques in the context of solving real-world and mathematical problems.

[CCSS.ELA-Literacy.RI.6.1](http://www.corestandards.org/ELA-Literacy/RI/6/1/)

Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

[CCSS.ELA-Literacy.RST.6-8.2](http://www.corestandards.org/ELA-Literacy/RST/6-8/2/)

Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

[CCSS.ELA-Literacy.RST.6-8.6](http://www.corestandards.org/ELA-Literacy/RST/6-8/6/)

Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

**PERFORMANCE EXPECTATIONS FOR UNIT**

MS-ETS1-1 Engineering Design

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 Engineering Design

Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3 Engineering Design

Analyze data from tests to determine similarities and differences among several different 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 Engineering Design

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.

CCSS Math Content 6. RPA 1: Understand ratio concepts and use ratio reasoning to solve problems.

**21st Century Skills:**

Students must communicate while also using data to support their claim.

Furthermore, students will work in small groups where they must collaborate to create, iterate and finalize designs. Students must also analyze, using a rubric, whether or not their final designs best fit the criteria while working within the constraints.

**Locally and/or Personally Relevant for Students:**

Given the current information regarding the potential of sending astronauts to Mars and the children’s discussions about The Martian (book and movie), we decided to capitalize on their interest and curiosity about events that could happen in their futures. Furthermore, our children need more experience with the engineering and design process. Finally, we wanted to create an interdisciplinary unit where life science (botany), nutrition, geometry (area), reading informational text and technology (Excel spreadsheets and research) skills joined together to represent the connectedness of numerous disciplines.

**Connections to career and educational pathways:**

Prior to the implementation of the lessons listed below, our students will spend time analyzing the requirements NASA currently lists in the quest to create a pool of astronauts for potential travel to Mars. Furthermore, because of the expertise of our higher education and industry volunteers, the teachers involved in the unit have more insight into the engineering and design process; thus, we plan to share our new learning with our students.

**Table of Content/Overview of Unit**

Lesson 1: Introduction to conceptual storyline

Lesson 2: Current status of Mars exploration

Lesson 3: Teambuilding exercise

Lesson 4: Explore engineering design process

Lesson 5: Explore constraints and criteria

Lesson 6: Introduce Excel tool

Lesson 7: Baseline food plan

**Lesson 8: Scaling up the plan**

Lesson 9: Iterate

Lesson 10: 2-D design phase

Lesson 11-14: 3-D design phase

**Learning Objectives:**

Having established a baseline for one day, the students are exposed to an equation using dimensional analysis that scales their calorie requirement up to account for the growth time of their chosen crops.

**Lesson Standards (NGSS, CCSS, CTE):**

[CCSS.ELA-Literacy.RST.6-8.2](http://www.corestandards.org/ELA-Literacy/RST/6-8/2/)

Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

[CCSS.ELA-Literacy.RST.6-8.6](http://www.corestandards.org/ELA-Literacy/RST/6-8/6/)

Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

**Materials**

* Science notebooks
* Excel worksheet file
* Computers
* Whiteboard / Chalkboard / DocCam

**Lesson Preparation**

* The instructor should be familiar with the concepts of dimensional analysis i.e., using units of measurement to develop equations.

**Time Required**: 45 minutes

**Grouping of Students for Instruction**

As sixth grade teachers, we decided to predetermine our groups to balance for mathematical ability (lots of ratio/proportion work), engineering and design background, reading level, ELL vs. highly capable, social skills, leadership skills, organization, etc.). The students all share the same “team” roles in this PBL; however, we know some may naturally gravitate toward particular tasks.

**Procedure[[1]](#footnote-1):**

Define/refine the Problem

* The baseline plan created in lesson 7 will only provide calorie requirements for one day. The plan must be scaled to accommodate the number of days it will take to grow each crop.

Gather Information

* Use a class discussion to walk through the calculations below.

The problem statement asks students to supply 1000 calories *per 1 person per 1 day*:

They already scaled that up to accommodate three researchers for the baseline plan:

Since the crops do not grow overnight, students now need to figure out the total calories their crops will need to support in order to account for the time it takes to grow their crops. In order to minimize the complexity of the problem, instruct students to use the max growing time from their baseline plan. In this example, we’ll use 30 days:

The result of the calculation, 90,000 in this example, is the real number of calories students must produce with their crops. After the first 30 days, they will have enough food to last the next 30 days while the next batch of crops is growing.

Resolve the Problem

After explaining the formula, students should calculate their own group’s calorie requirement using the maximum growth time of the crops in their baseline plan. They will then modify their plan to achieve the new calorie target. They may do this by changing quantities or changing the chosen crops or both. However, the crop with the longest growth time must remain in their plan. This prevents the students from having to repeatedly recalculate their calorie requirements.

The new plan should be saved and labeled as revision 1.

**Assessment:**

* Equation showing how students arrived at their revised calorie requirement.
* Revised crop plan to achieve the new calorie requirement.

**Accommodations:**

* Engineering profile could be turned into a Google Doc for word processing if handwriting an issue.
* Teacher will be reading and rereading assignment.
* Classrooms have microphones for hearing impaired.
* Teachers could also enlarge any documents under document camera.

**Extensions:**

* The instructor may choose to add complexity to the module by allowing students to change their crop with the longest growing time.

**References/Resources:**

**Works Cited (MLA JR)**

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Rusch, Elizabeth. The Mighty Mars Rovers. Boston: Houghton Mifflin, 2012. Print.

“Who will fly on mission to Mars? Crew members must have the right stuff.” Newsela. Newsela, 25 Feb. 2016. Web. 14 Mar. 2016. <https://newsela.com/>.

1. The sub-sections of the procedure section (e.g., Understand the Problem, Explore the Problem) are from the Illinois Math and Science Academy’s PBL Teaching and Learning Template, however, the descriptions were developed by WABS and do not necessarily represent the views of IMSA. [↑](#footnote-ref-1)