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5-E Classroom STEM Activity:
Measuring Mars

Dr. Alexandra Owens

Manufacturing a Clearer View of Mars and Beyond

By Dorothy Crouch

Working with colleagues who have different backgrounds and expertise to make products that help people learn more is one of the most important aspects of manufacturing.

Optimax President Mike Mandina and optical coating technician Tsion Teklemarim have very different jobs, but they depend on each other to make sure important projects—such as creating the optics for NASA's Mars Rovers—are successful.

While Mike is now the leader at Optimax, he started in manufacturing in the same way many other kids find themselves interested in the field—taking things apart and trying to rebuild them at home.

"I liked to tinker with things to see how they worked. I remember disassembling my sister's toy piano to see how it made sound," remembers Mike. "Unfortunately, I could not get it back together. That was not a good day for me!"

When looking back on her start in manufacturing, Tsion realized she had the same spark.

"I was always interested in how things work, what they were made from and how they operate, which led me to be more involved in the manufacturing world," she says.

Though Mike has been working in the field much longer than Tsion, they are both proud of the accomplishments of their company and the work they continue to do with NASA. Optimax created optics for the different Mar Rovers, including the first that landed on Mars in 1997 and the New Horizons spacecraft that traveled to the solar system's edge, but also photographed Pluto during the trip, according to Mike.

"It was a privilege to be asked by NASA to manufacture more optics for the 2020 Rover," he says. "We feel tremendous pride in participating in projects like this that will ultimately benefit mankind."

Working with NASA is exciting, but it means that many different manufacturing specialists are needed to finish these important projects. As part of the team that makes optics for the 2020 Rover, Tsion relies on her coworkers and they rely on her specialized work.

"The 2020 Rover project is a result of so many hands. My involvement in this project is delivering the specific coating design by monitoring the machines' outcome and ensuring the results," she says, but her role involves additional responsibilities including troubleshooting and maintenance.

When thinking about the future of manufacturing, Tsion sees an expanding industry for today's students. For students who have a strong desire to learn, she sees a lot of opportunities to grow and succeed as new needs will bring about more jobs in the field.

"The manufacturing industry has a great impact in society today and continues to grow fast with human needs," she says. "There will be a lot of innovation and new career paths in the future in this field."

As the leader of the largest optics manufacturing company in the United States, Mike believes the future of manufacturing is in automation, but there will be a need for educated professionals who specialize in process engineering, quality control, optics manufacturing, technical coating, purchasing, training, sales, information technology (IT), and finance.

While he doesn't recommend kids start taking apart everything in their houses—especially without a parent's permission—he advises students to begin taking coursework in technology, humanities, and business, and finding part-time jobs in the field.

"Students, counselors, and parents should all understand that entry-level manufacturing jobs are a powerful gateway to enjoyable and living-wage sustainable careers," says Mike. "I started grinding lenses on a night shift and ended up owning an optics company with more than 300 employees."

MIKE MANDINA
PRESIDENT, OPTIMAX SYSTEMS, INC.
DEGREES:
- ASSOCIATE DEGREE IN OPTICAL ENGINEERING TECHNOLOGY & SCIENCE
- BACHELOR'S IN APPLIED PHYSICS
- EXECUTIVE MASTER'S OF BUSINESS ADMINISTRATION

YEARS IN THE INDUSTRY: 45
STEM TYPE: MAKER

TSION TEKLEMARIM
OPTICAL COATING TECHNICIAN
TRAINING: PRECISION TOOLING AND MACHINING CERTIFICATE
YEARS IN THE INDUSTRY: 2
STEM TYPE: EXPLORER

Photo: provided by Optimax Systems, Inc.

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5-E Classroom STEM Activity: Measuring Mars

Here are some ideas for how middle school teachers could use this story as a launching point for integrated STEM learning. Our activities follow the 5-E Learning Cycle Model.

Part 1: Engage

1. Ask students what they know about Mars. How have scientists been able to gather data about Mars?
2. Have students read the article "Manufacturing a Clearer View of Mars and Beyond" in *STEM Jobs* magazine. Discuss the following questions:
    a. Have you ever taken something apart to see how it works?
    b. How are optics used for the Mars Rovers and other space missions?
    c. Even with the rise in automation, how will the manufacturing field still grow?
    d. What are some ways to prepare for a career in manufacturing?
3. Show the video "The Next Mission to Mars: Mars 2020" found at edu.STEMjobs.com/teacher-resources. Stop at 3:48 as an introduction, or play the entire video for an in depth scientific explanation of the evidence collected in prior missions, and plans for Mars 2020.
4. If time, also show the video "NASA Begins Building Next Mars Rover Mission" to give an overview of the mission itself.

Part 2: Explore

1. Break students into small groups of three or four. Ask students to consider what data they think should be collected from Mars during the Mars 2020 mission. What makes this data important? How can this data be collected?
2. Present the challenge to the students: Design an instrument that should be included on the Mars 2020 Rover. Your instrument should contribute to the overall mission of Mars 2020 by collecting samples that will provide data pertinent to determining if there is or was life on Mars.
3. Encourage students to research instruments used on past Mars missions, including the optics described in the article. As a teacher reference only, a description of the instruments currently included on the Mars 2020 Rover can be found on the website "Mars 2020 Instruments - A Plan for Sample Return" available at edu.STEMjobs.com/teacher-resources.
4. Provide time for students to research and design their instrument. Students may draw their design by hand, or if desired, allow groups to utilize free CAD software to create a digital design. If this software is not available on your school computers, use a free online resource listed at edu.STEMjobs.com/teacher-resources.
5. Have groups create a presentation to share their instrument design for feedback.

Part 3: Explain

1. Pair groups so each can present their instrument design to another group in class. Students should share their research, design, and a description of data collection using presentation software such as PowerPoint or Google Slides if personal devices are available. Students should explain their instrument and how their instrument contributes to the Mars 2020 mission.
2. Encourage groups to ask questions and provide constructive critique following the presentation. Feedback will be essential for the next part of the lesson.

Part 4: Elaborate

1. Present an extension to the student challenge: NASA can only select a few instruments to include on the rover due to restricted size, weight, and budget requirements. They are now accepting proposals from teams of scientists for consideration. Create a proposal to NASA for your instrument to be part of the Mars 2020 Rover. The proposal should include a description of the instrument (including its size and cost), how samples are collected, and its contribution to the overall Mars 2020 mission.
2. Provide time for students to create their proposal while considering the feedback provided from their partner group. Additional research may be needed to determine costs.
3. Have students share their final proposals with a class presentation. Invite school administration, space science faculty, and community members (like those working in the manufacturing industry) to attend.

Part 5: Evaluate

Students will be evaluated for their design, presentation and proposal using the following rubric. Provide the rubric at the beginning of the lesson to clarify expectations and objectives. Each group will be graded, therefore all students in the group will receive the same score.

Scoring Rubric

____ **/20 Design Presentation**
Was research on Mars Rovers and instruments completed?
Did they consider this in their design?
Did the presentation summarize the design and its contributions?

____ **/20 Proposal**
Did the proposal include a description of the instrument, how samples are collected, and its contribution to the Mars 2020 mission?
Was the presentation clean and easy to understand?

____ **/10 Participation**
Did each student contribute to the design and proposal?
Did each student assist in providing and responding to group feedback?

____ **/50 Total**

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Standards Addressed:

Common Core State Standards - Math

CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.
CCSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively.
CCSS.MATH.PRACTICE.MP4 Model with mathematics.
Possible Standards Include:
CCSS.MATH.CONTENT.6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.
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.NS.C.5 Understand that positive and negative numbers are used together to describe quantities having opposite directions or values
(e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers
to represent quantities in real-world contexts, explaining the meaning of 0 in each situation.
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.SP.A.1 Recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers.
CCSS.MATH.CONTENT.6.SP.B.5.B Summarize numerical data sets in relation to their context, such as by:
B. Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.
CCSS.MATH.CONTENT.7.RP.A.2.C Represent proportional relationships by equations.
CCSS.MATH.CONTENT.7.RP.A.3 Use proportional relationships to solve multistep ratio and percent problems.
CCSS.MATH.CONTENT.7.EE.B.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers,
fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess
the reasonableness of answers using mental computation and estimation strategies.
CCSS.MATH.CONTENT.7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities
to solve problems by reasoning about the quantities.
CCSS.MATH.CONTENT.7.SP.A.1 Understand that statistics can be used to gain information about a population by examining a sample of the population;
generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends
to produce representative samples and support valid inferences.
CCSS.MATH.CONTENT.7.SP.A.2 Use data from a random sample to draw inferences about a population with an unknown characteristic of interest.
Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions.
CCSS.MATH.CONTENT.8.EE.A.3 Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities,
and to express how many times as much one is than the other.

Common Core State Standards - ELA

CCSS.ELA-LITERACY.RI.6.7 Integrate information presented in different media or formats (e.g., visually, quantitatively)
as well as in words to develop a coherent understanding of a topic or issue.
CCSS.ELA-LITERACY.W.6.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts,
and information through the selection, organization, and analysis of relevant content.
CCSS.ELA-LITERACY.W.6.7 Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry when appropriate.
CCSS.ELA-LITERACY.W.6.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.
CCSS.ELA-LITERACY.W.6.10 Write routinely over extended time frames (time for research, reflection, and revision)
and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.
CCSS.ELA-LITERACY.SL.6.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led)
with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.
CCSS.ELA-LITERACY.SL.6.4 Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts,
and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.
CCSS.ELA-LITERACY.SL.6.5 Include multimedia components (e.g., graphics, images, music, sound) and visual displays in presentations to clarify information.
CCSS.ELA-LITERACY.W.7.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts,
and information through the selection, organization, and analysis of relevant content.
CCSS.ELA-LITERACY.W.7.7 Conduct short research projects to answer a question, drawing on several sources and generating additional related,
focused questions for further research and investigation.
CCSS.ELA-LITERACY.W.7.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.
CCSS.ELA-LITERACY.W.7.10 Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames
(a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.
CCSS.ELA-LITERACY.SL.7.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led)
with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.
CCSS.ELA-LITERACY.SL.7.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions,
facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.
CCSS.ELA-LITERACY.SL.7.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.
CCSS.ELA-LITERACY.W.8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts,
and information through the selection, organization, and analysis of relevant content.
CCSS.ELA-LITERACY.W.8.7 Conduct short research projects to answer a question (including a self-generated question),
drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Standards Addressed (Cont.):

Common Core State Standards - ELA (Cont.):

CCSS.ELA-LITERACY.W.8.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.
CCSS.ELA-LITERACY.W.8.10 Write routinely over extended time frames (time for research, reflection, and revision)
and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.
CCSS.ELA-LITERACY.SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led)
with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.
CCSS.ELA-LITERACY.SL.8.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence,
sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.
CCSS.ELA-LITERACY.SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

Next Generation Science Standards

Possible Standards Include:
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.
Science and Engineering Practices
Asking Questions and Defining Problems. Define a design problem that can be solved through the development of an object, tool,
process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.
Disciplinary Core Ideas
ETS1.A: Defining and Delimiting Engineering Problems
The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful.
Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.
Crosscutting Concepts
Influence of Science, Engineering, and Technology on Society and the Natural World.
All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
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-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
Science and Engineering Practices
Engaging in Argument from Evidence. Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.
Disciplinary Core Ideas
ETS1.B: Developing Possible Solutions
There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.

MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
Science and Engineering Practices
Constructing Explanations and Designing Solutions. Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students'
own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
Crosscutting Concepts
Cause and Effect. Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

ISTE Standards for Students

1d Students understand the fundamental concepts of technology operations, demonstrate the ability to choose,
use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.
4b Students select and use digital tools to plan and manage a design process that considers design constraints and calculated risks.
4c Students develop, test and refine prototypes as part of a cyclical design process.
6a Students choose the appropriate platforms and tools for meeting the desired objectives of their creation or communication.
6b Students create original works or responsibly repurpose or remix digital resources into new creations.
6c Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations.
6d Students publish or present content that customizes the message and medium for their intended audiences.

Standards Addressed (Cont.):

Texas Essential Knowledge and Skills- Math

6-8.1.A apply mathematics to problems arising in everyday life, society, and the workplace.
6-8.1.B use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution.
6-8.1.D communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate.
6-8.1.E create and use representations to organize, record, and communicate mathematical ideas.
Possible Standards Include:
6.4.E represent ratios and percents with concrete models, fractions, and decimals
6.5.A represent mathematical and real-world problems involving ratios and rates using scale factors, tables, graphs, and proportions
6.9.A write one-variable, one-step equations and inequalities to represent constraints or conditions within problems
7.4.A represent constant rates of change in mathematical and real-world problems given pictorial, tabular, verbal, numeric, graphical, and algebraic representations, including d = rt
7.4.D solve problems involving ratios, rates, and percents, including multi-step problems involving percent increase and percent decrease, and financial literacy problems
7.6.F use data from a random sample to make inferences about a population
7.10.A write one-variable, two-step equations and inequalities to represent constraints or conditions within problems
7.12.B use data from a random sample to make inferences about a population
8.5.H identify examples of proportional and non-proportional functions that arise from mathematical and real-world problems
8.11.C simulate generating random samples of the same size from a population with known characteristics to develop the notion of a random sample being representative of the population from which it was selected

Texas Essential Knowledge and Skills- Science

Possible Standards Include:
6-8.3.A analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, so as to encourage critical thinking by the student
6.5.A know that an element is a pure substance represented by a chemical symbol and that a compound is a pure substance represented by a chemical formula
6.11.A describe the physical properties, locations, and movements of the Sun, planets, moons, meteors, asteroids, and comets
6.11.C describe the history and future of space exploration, including the types of equipment and transportation needed for space travel
6.12.A understand that all organisms are composed of one or more cells
7.9.A analyze the characteristics of objects in our solar system that allow life to exist such as the proximity of the Sun, presence of water, and composition of the atmosphere
8.5.A describe the structure of atoms, including the masses, electrical charges, and locations, of protons and neutrons in the nucleus and electrons in the electron cloud
8.5.B identify that protons determine an element's identity and valence electrons determine its chemical properties, including reactivity
8.5.C interpret the arrangement of the Periodic Table, including groups and periods, to explain how properties are used to classify elements
8.5.D recognize that chemical formulas are used to identify substances and determine the number of atoms of each element in chemical formulas containing subscripts
8.11.A investigate how organisms and populations in an ecosystem depend on and may compete for biotic factors such as food and abiotic factors such as quantity of light, water, range of temperatures, or soil composition