DESIGNING A MODEL MARS ROVER POWERED BY SOLAR ENERGY

An Aerospace Lesson Plan by Kevin Hubbard

Summary

Grade Levels: 4th Grade
Duration: One to two 60-minute class periods (can be extended over several days)
Lesson Overview: In this hands-on lesson, students work collaboratively to design, build, test, and improve model Mars rovers powered by solar panels. They integrate key concepts of aerospace engineering with essential math skills—including multiplication, division, decimals, and factors/multiples—to solve real-world problems. Students will also develop academic language and practice collaboration throughout this STEAM challenge.
Subject Areas: STEAM Integration (Mathematics, Science, Engineering, and Language Development)

Learning Objectives

- **Mathematics:**
    - Multiply multi-digit numbers using area models to calculate the solar panel's area.
    - Divide whole numbers (up to four digits by one digit) to model equally shared energy.
    - Represent and compare decimals (to the nearest tenth/hundredth) in measurement tasks.
    - Identify factor pairs and common multiples to optimize rover wheel rotations.
- **Science and Engineering:**
    - Explain how solar panels convert sunlight into energy for powering rovers.
    - Apply the engineering design process (plan, build, test, redesign) to improve rover designs.
    - Use cause-and-effect reasoning to connect design modifications to improved rover efficiency.
- **English Language Development (ELD):**
    - Use academic vocabulary (e.g., solar energy, area, factor, multiple) during problem-solving and oral/written explanations.

  - Participate in group discussions using sentence frames (e.g., "Our rover works because…", "We calculated the area by…") to support academic language development.
  - Clearly present mathematical reasoning and design choices through diagrams, posters, and oral presentations.

Materials & Resources

Math and Measurement Tools:

- ☐ Grid paper (for area models and arrays)
- ☐ Centimeter rulers (for accurate decimal measurements)
- ☐ Base-10 blocks (to visualize multiplication and division)
- ☐ 100 charts (for practicing factors and multiples)
- ☐ Counters or snap cubes
- ☐ Computer with Internet connectivity to show NASA video clip

Rover Design Supplies:

- ☐ Construction paper (to represent solar panels)
- ☐ LEGO kits, cardboard, or recycled materials for rover construction
- ☐ Scissors, tape, and glue
- ☐ Markers, colored pencils, and chart paper for posters

Technology and Visual Supports:

- ☐ Projector or document camera (for displaying a NASA rover video and math models)
- ☐ Optional tablets/computers (for digital simulations or research)
- ☐ Images of Mars rovers and solar panels

ELD and Language Supports:

- ☐ Word banks with key vocabulary (solar energy, area, factor, multiple, quotient, decimal)
- ☐ Sentence frames (provided on chart paper or handouts)
- ☐ Bilingual vocabulary cards as needed

Optional Engagement Extras:

- ☐ Small toy cars (to simulate rover movement)
- ☐ Measuring tape for extended design challenges

Vocabulary

- **Solar Energy Concepts:**
  - Solar Panel, Photovoltaic Cell, Energy Conversion, Sunlight
- **Engineering Process:**
  - Prototype, Iteration, Redesign, Optimization

- **Rover Components:**
  - Chassis, Wheel Assembly, Solar Array, Suspension
- **Mathematical Strategies:**
  - Area Calculation, Factors & Multiples, Decimal Measurement, Equitable Division
- **Other Relevant Terms:**
  - Efficiency (maximizing energy use), Scalability (adjusting model size for accuracy)

Instructional Procedures

- **Engage (10 Minutes):**
  - *Hook:* Show a short NASA video clip featuring a Mars rover in motion.
  - *Discussion:* Ask guiding questions such as, "How does the rover move when there are no gas stations on Mars?" and "How might a solar panel help power the rover?"
  - *Academic Vocabulary Preview:* Introduce key terms (solar panel, energy, area, factor, multiple) using a quick call-and-response with associated motions (e.g., arms wide for "area").
  - *Sentence Frames:* Provide frames such as "The rover moves because..." to prompt partner discussion.
- **Explore (15-20 Minutes):**
  - *Rover Model Challenge:* Divide students into small groups and have them construct a simple rover using provided materials (paper, cardboard, LEGOs). Each team should incorporate a solar panel into their model.
  - *Mathematics Integration:*
    - Calculate the area of the solar panel (multiplication using area models).
    - Model energy sharing by dividing energy units among parts of the rover.
    - Use rulers to measure dimensions in centimeters, recording the values as decimals.
    - Explore factors and multiples by considering how the wheels rotate.
  - *ELD Supports:* Provide bilingual math word banks and sentence starters to aid group discussions (e.g., "Our solar panel's area is...").
- **Explain (15 Minutes):**
  - *Group Sharing*: Each team presents their rover model and explains their mathematical calculations (area, division, decimal measurements, use of factors/multiples).
  - *Guided Discussion*: Lead a whole-class conversation with guiding questions:
    - "How did you determine the area of your solar panel?"
    - "What does your division strategy tell us about sharing energy?"
    - "How did decimals help in measuring your rover's parts?"
  - *Teacher Clarification*: Use visual supports (drawings, base-10 blocks, area models) on the board to reinforce mathematical concepts.

- **Elaborate (15 Minutes):**
  - *Redesign Challenge:* In their teams, students review their initial designs and use evidence from their calculations to choose one improvement (e.g., increasing the solar panel size, optimizing wheel rotation, adjusting energy division).
  - *Collaboration:* Teachers circulate, asking probing questions like, "How does your new design improve the rover's efficiency?" and encouraging the use of academic language (e.g., "Our new design is better because…").
  - *Mathematics Re-Application:* Students recalculate measurements or test new configurations, comparing new data to initial calculations.
- **Evaluate (10 Minutes):**
  - *Presentations:* Each group creates a mini poster that includes:
    - A drawing of their redesigned rover
    - At least one math equation (demonstrating multiplication, division, decimals, or factors/multiples)
    - A verbal or written explanation, using academic vocabulary, of why the design improvement was effective
  - *Gallery Walk/Oral Sharing:* Groups share their posters in a gallery walk or through brief oral presentations.
  - *Formative Assessment:*
    - Review each group's use of correct math concepts and academic vocabulary
    - Observe collaborative discussions and use of sentence frames
    - Collect exit prompts where students write "One way math helped us design our rover today was…" and "One thing I learned about solar panels and energy is…"

Standards Alignment

- **Next Generation Science Standards (NGSS):**
  - PS3.B: Conservation of Energy and Energy Transfer
  - ETS1.A/B/C: Engineering Design (defining problems; developing and optimizing
  - solutions)
  - Cross-Cutting Concepts: Cause and Effect, Systems and System Models,
  - Scale/Proportion, Energy and Matter
- **Common Core Mathematics Standards (Grade 4):**
  - 4.NBT.B.5 – Multiplication using area models
  - 4.NBT.B.6 – Division strategies based on place value
  - 4.NF.C.6–7 – Decimal notation and comparison
  - 4.OA.B.4 – Identifying factor pairs and classifying numbers
- **Common Core English Language Arts & ELD Standards (Grade 4):**
  - SL.4.1 – Collaborative Discussions
  - W.4.2 and RI.4.7 – Explanatory writing and interpretation of visuals/information
  - ELD Standards 1-3 – Collaborative, interpretive, and productive language use

Assessment:

- **Formative Assessment:** Monitor group discussions, review quick writes and exit slips, and use a checklist to ensure correct math application and clear explanations.
- **Summative Assessment:** Evaluate posters and oral presentations based on clarity of reasoning, correct use of mathematics, integration of science concepts, and effective use of academic vocabulary.

Differentiation & Supports:

- **Differentiation:** Provide additional visuals, bilingual supports, or hands-on manipulatives for students who need further reinforcement.
  - Extending activities to challenge advanced students (e.g., incorporating additional measurements or exploring more complex design iterations).

Teacher Reflection

After the lesson, reflect on the following:

- Were the mathematical concepts clearly connected to the engineering design process?
- Did students engage effectively with the academic language and use of sentence frames?
- How could the lesson be modified to better support diverse learners or extend learning for advanced students?

This lesson plan provides a structured yet flexible framework for integrating math and science concepts through an engaging, hands-on engineering challenge that emphasizes collaboration, critical thinking, and strong academic language development.
