Matter

Physical Science | Lesson Guide

5th Grade

Photo Description

This image shows a modern sculpture made of curved metal arches that create flowing, wave-like shapes in front of buildings. The shiny metal structures reflect light and appear to be made of stainless steel or aluminum. Palm trees and landscaping surround the artistic installation, which demonstrates how engineers design structures that are both beautiful and strong.

Scientific Phenomena

The anchoring phenomenon here is structural engineering and materials science in action. The curved metal arches demonstrate how engineers use the properties of metals - specifically their strength, flexibility, and resistance to weathering - to create structures that can withstand various forces while maintaining their shape. The curves distribute weight and stress evenly throughout the structure, making it more stable than straight beams would be. The reflective surface shows how light interacts with smooth metal surfaces through reflection.

Core Science Concepts

1. Materials and Their Properties: The metal arches are made from materials chosen for specific properties like strength, durability, and resistance to corrosion from weather.

2. Forces and Motion: The curved design helps distribute forces (like wind, gravity, and thermal expansion) throughout the structure, preventing failure at any single point.

3. Light and Reflection: The polished metal surface reflects light rays at predictable angles, creating the shiny appearance we observe.

4. Engineering Design Process: This sculpture represents how engineers identify problems (creating attractive, durable public art), develop solutions, and test materials to meet specific criteria.

Pedagogical Tip:

Have students physically test different shapes using clay or playdough to see which designs are strongest when weight is applied. This hands-on experience helps them understand why engineers choose curved designs over straight ones.

UDL Suggestions:

Provide multiple ways for students to explore this concept: visual learners can examine photos and diagrams, kinesthetic learners can build and test structures with blocks or straws, and auditory learners can discuss their observations with partners.

Zoom In / Zoom Out

1. Zoom In: At the molecular level, the metal's crystal structure gives it strength. The atoms are arranged in regular patterns that allow the material to flex slightly under stress without breaking, and the smooth surface creates uniform reflection of light photons.

2. Zoom Out: This sculpture is part of a larger urban planning system where public art serves multiple functions - beautifying spaces, creating landmarks for navigation, and demonstrating community values about science and engineering. It connects to the broader human need to solve problems through engineering design.

Discussion Questions

1. Why do you think the engineers chose to make these arches curved instead of straight? (Bloom's: Analyze | DOK: 3)

2. What properties would the metal need to have to work well for this outdoor sculpture? (Bloom's: Evaluate | DOK: 2)

3. How might this structure perform differently if it were made from wood or plastic instead of metal? (Bloom's: Synthesize | DOK: 3)

4. What forces do you think this sculpture needs to withstand in its outdoor environment? (Bloom's: Apply | DOK: 2)

Potential Student Misconceptions

1. Misconception: "Curved structures are weaker than straight ones because they look flimsy."
   Clarification: Curved structures often distribute forces more effectively than straight ones, making them stronger and more stable.

2. Misconception: "All metals are the same and have identical properties."
   Clarification: Different metals and metal alloys have varying properties like strength, flexibility, and resistance to rust, which is why engineers choose specific materials for specific jobs.

3. Misconception: "Reflection only happens with mirrors."
   Clarification: Any smooth, shiny surface can reflect light, including polished metals, water, and glass.

Cross-Curricular Ideas

1. Math - Geometry and Measurement: Have students measure the angles and curves of the arches using protractors and rulers. They can calculate the perimeter of curved shapes and compare the measurements of different sections of the sculpture. This connects to understanding how mathematical principles guide engineering design.

2. ELA - Descriptive Writing: Students can write detailed descriptions of the sculpture, using sensory words to describe what they see, hear (wind moving around it), and feel (the temperature of metal in sun). They could also research and write about the artist or engineer who designed it, creating an informational text.

3. Social Studies - Community and Design: Explore how public art sculptures like this one serve communities. Students can research other famous sculptures or public art installations in their region and discuss how they bring people together, create landmarks, and reflect what communities value about science and creativity.

4. Art - Form and Function: Students can create their own curved sculptures using materials like wire, foam, or clay, experimenting with how different curves and angles affect the overall appearance and stability of their designs. This hands-on experience deepens understanding of how form (shape) and function (purpose) work together in art and engineering.

STEM Career Connection

1. Structural Engineer: Structural engineers design and test buildings, bridges, sculptures, and other large structures to make sure they're safe and strong. They use math and science to figure out what materials work best and how to shape them so they won't break or fall down. These professionals earn an average annual salary of $85,000-$95,000 USD.

2. Materials Scientist: Materials scientists study different materials like metals, plastics, and composites to discover their properties and find new ways to use them. They test how materials perform under different conditions and help engineers choose the right material for each job. These professionals earn an average annual salary of $95,000-$105,000 USD.

3. Public Art Designer/Sculptor: Artists and designers who create sculptures and public installations use their creativity combined with engineering knowledge to design structures that are beautiful and safe. They work with engineers and communities to create art that people can enjoy in public spaces. These professionals earn an average annual salary of $55,000-$75,000 USD (varies widely based on commissions and projects).

NGSS Connections

- Performance Expectation: 5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.
- Disciplinary Core Ideas: 5-PS1.A (Structure and Properties of Matter), K-2-ETS1.A (Defining and Delimiting Engineering Problems)
- Crosscutting Concepts: Structure and Function, Patterns
- Science and Engineering Practices: Developing and Using Models, Planning and Carrying Out Investigations

Science Vocabulary

* Reflection: When light bounces off a surface at an angle equal to the angle it hits the surface.
* Properties: The special characteristics that make a material useful for certain jobs.
* Structure: The way parts are arranged and connected to make something strong and stable.
* Force: A push or pull that can change how an object moves or its shape.
* Engineer: A person who uses science and math to design and build solutions to problems.
* Alloy: A mixture of metals that combines the best properties of each metal.

External Resources

Children's Books:
- The Most Magnificent Thing by Ashley Spires
- Bridges! Amazing Structures to Design, Build & Test by Carol A. Johmann
- Material World: A Substantial Story of Our Past and Future by Ed Conway