JOURNEY through the UNIVERSE

Voyage: A Journey through our Solar System

Grades 3-4

Lesson 1: Modeling Patterns and Cycles in Our Lives

On a visit to the National Mall in Washington, DC, one can see monuments of a nation—Memorials to Lincoln, Jefferson, and WWII, the Vietnam Veterans Memorial Wall, and Washington Monument. Standing among them is *Voyage*—a one to 10-billion scale model of our Solar System—spanning 2,000 feet from the National Air and Space Museum to the Smithsonian Castle. *Voyage* provides visitors a powerful understanding of what we know about Earth's place in space and celebrates our ability to know it. It reveals the true nature of humanity's existence—six billion souls occupying a tiny, fragile, beautiful world in a vast space.

Voyage is an exhibition that speaks to all humanity. The National Center for Earth and Space Science Education is therefore making replicas of *Voyage* available for permanent installation in communities worldwide (http://voyagesolarsystem.org.)

This lesson is one of many grade K-12 lessons developed to bring the *Voyage* experience to classrooms across the nation through the Center's *Journey through the Universe* program. *Journey through the Universe* takes entire communities to the space frontier (http://journeythroughtheuniverse.org.)

The *Voyage* exhibition on the National Mall was developed by Challenger Center for Space Science Education, the Smithsonian Institution, and NASA.

Lesson 1: Modeling Patterns and Cycles in Our Lives

Lesson at a Glance

Lesson Overview

Many observable phenomena are associated with predictable cycles and patterns in nature. Sometimes these phenomena are difficult to see, so we build and use models to understand cycles and patterns such as the seasons, the water cycle, or sunrise and sunset. By using the Earth as a prototype, students come to realize that similar patterns and cycles may also exist on other planets.

Lesson Duration

Two 45-minute class periods

Core Education Standards

AAAS Benchmarks for Science Literacy

Benchmark 11B4:

- Models are very useful for communicating ideas about objects, events, and processes. When using a model to communicate about something, it is important to keep in mind how it is different from the thing being modeled.

Benchmark 11C4:

- Some things in nature have a repeating pattern, such as the day-night cycle, the phases of the moon, and seasons.

Related Education Standards

National Science Education Standards

Standard D2: Objects in the sky

- The Sun, Moon, stars, clouds, birds, and airplanes all have properties, locations, and movements that can be observed and described.

AAAS Benchmarks for Science Literacy

Benchmark 2A1:

- Mathematics is the study of quantity and shape and is useful for describing events and solving practical problems.

Benchmark 11B2:

- Geometric figures, number sequences, graphs, diagrams, sketches, number lines, maps, and oral and written descriptions can be used to represent objects, events, and processes in the real world.

Essential Question

- How does building a model help us better explore the natural world?

Concepts

Students will learn the following concepts:

- Models are two- or three-dimensional representations that share one or more characteristics of the object you want to study.
- Many patterns and cycles exist in nature; these patterns and cycles are often difficult to see.
- Models can help us to analyze and study these patterns and cycles.

Objectives

Students will be able to do the following:

- Identify common cycles or patterns in nature.
- Demonstrate an understanding of models by identifying examples of models in the classroom.
- Create a model to visually represent a basic cycle or pattern in nature.

Science Overview

Recognizing Cycles and Patterns

There are many cycles that exist in the natural world. These cycles are events that repeat themselves in a certain pattern, time after time. For example, the Sun appears to rise every morning and set every evening. Bears hibernate each winter and emerge each spring hungry. Animals also go through a life cycle. For example, frogs start off as eggs, hatch into tadpoles, and grow into frogs. Before they die, frogs lay eggs and start a new life cycle again.

Familiar patterns children should recognize in their lives include the following:

- The waking and sleeping cycle
- The feeling of hunger at periodic intervals
- Monday through Friday school attendance, with weekend breaks
- Regular schedules of homework, practice, exercise, chores, etc.

Some patterns they should begin to recognize in their surroundings may include the following:

- Appearance of the Sun daily
- Sunrise and sunset
- Day-to-night changes in temperature
- Changes in temperature and weather during the year
- The four seasons (summer, fall, winter, spring)
- Regulated passage of time (calendar, clock, stopwatch, etc.)

Other patterns some students may recognize:

- The birth-growth-death cycle of people, plants, and animals
- The water cycle (evaporation, condensation, precipitation)
- Tides

Less obvious patterns that a few students may recognize:

- Apparent movement of the Sun, Moon, and stars across the sky
- Appearance of the Moon and stars almost nightly
- Phases of the Moon and its monthly cycle

Definition of a Model

For the purposes of the Grades 3-4 *Voyage* Unit, models are defined as representations that are either physical (three-dimensional with surface and mass, or two-dimensional "flat"), or mathematical, sharing one or more characteristics of the object you want to study.

The purpose of a model is to represent an object or a phenomenon in a manageable way, and learn about a real object or phenomenon by making a model that is simpler or more manageable than the real thing.

Some ways to make real objects more accessible include making models that are larger or smaller, colder or hotter than the real object. For example, three-dimensional and flat models may be smaller copies of their counterparts, (e.g. model train, toy car, map of a city, photograph of a car). They may also include bigger versions to illustrate objects usually too small for study (e.g., molecules illustrated with wood balls and wire, handwriting shown on enlarged charts). Other versions may help in exploring things too hot for study (e.g., a play kitchen oven, with colored paper cut to the shape of a flame) or too cold for study (e.g., a snowman rebuilt in styrofoam, an igloo made of plastic). A physical model can also be an abstraction of a real object or phenomenon, like an illustration showing the life cycle of a frog.

Mathematical models are quantitative or symbolic representations of a concept, process, or phenomenon. For example, the multiplication tables reflect a shortcut to the process of counting. A bar chart may indicate the most popular ice cream flavors. The countdown process represents the liftoff procedures for a spacecraft.

Proportion in Scale Models

A physical model is particularly useful if it is a scale model. This means that all parts of the model are scaled up or down by the same factor. If you have a 1/50 scale model of an airplane, then the length of the model wing is 1/50 the length of the real wing, the height of the tail is 1/50 the height of the real tail, etc. Caution: Areas and volumes will not scale the same way. For example, the real airplane will contain much more than 50 times the volume of the 1/50 scale model.

Professional Need for Models

Models are not just toys. Scientists, engineers, architects, and other professionals use them to see how parts fit together, how something will look from different angles, how much bigger some parts are than others, or whether a new kind of product will actually work. Certain model characteristics are essential to represent an object, but the characteristics chosen depend upon the model's purpose.

For any kind of model, its purpose is to show one or more characteristics of the actual object, though it does not usually portray them all. However, some models are perfect replicas and may be used in simulations and re-enactments, historical films, safety tests, or in museum exhibits.

Many details may be omitted from models, since their inclusion could make the model unnecessarily complicated. Often, the characteristic not accurately conveyed is size, though on a scale model, at least the relative size of parts is correct.

Another characteristic you would not want to accurately represent is the temperature of a very hot object, such as the Sun. Other model characteristics might include: color, shape, density, texture, weight, smell, taste, sound, and physical state (solid, liquid, or gas).

A Few Generalizations About Models

- A model is often bigger or smaller than the real object. Models are typically made at a size that make them comfortable to manipulate, so that they are easier to study than the real object.
- A model may be a perfect replica; the same size as the real object with all the same characteristics.
- A model does not always work like the real thing.
- A model is not always made of the same materials as the real object.
- A model can be flat (2-D picture) or have the complete physical shape (3-D) of the actual object.
- A model can be a mathematical or graphic representation of something, such as a chart or an equation.
- A model may represent an object, a phenomenon, or a concept.

NOTES:

Conducting the Lesson

Warm-Up & Pre-Assessment

Teacher Materials

- *Earth Cycles* by Ross & Moore

Preparation & Procedures

1. If you have the book *Earth Cycles* by Ross & Moore read it aloud to the students. Have them identify the different cycles discussed.

2. If *Earth Cycles* or a similar book is unavailable, ask students to identify cycles and patterns in their lives and in nature. Prompt them, if necessary, with questions about what they do every hour, day, week, and year. Ask them to think about plants and trees, the weather, animals, water, and other natural phenomena. (See *Science Overview* for examples).

3. Keep a record of the students' responses.

NOTES:

Activity: Patterns and Cycles

Students conduct an activity with three parts; first, they discuss cycles and patterns in nature, then they define and identify models, and finally they build a popsicle model of a cycle.

Teacher Materials

- Sample classroom models (e.g., firetruck, car, stuffed toy, illustration of the water cycle or life cycle of frog, etc.)
- Masking tape
- 10 3”x5” notecards or colored paper per group, plus teacher
- Colored pens
- 10 popsicle sticks per group, plus teacher

Part 1) Discuss Cycles and Patterns in Nature

Preparation & Procedures

1. Discuss some of the cycles or patterns students suggested. Ask about different processes they list. Have them try to explain why these cycles occur. For example:
   - Why do you think you are not always hungry?
   - Why is your daily schedule (e.g., waking up, having breakfast, going to school, eating dinner, doing your homework, sleeping) set up the way it is?
   - What changes around you indicate the passage of seasons? Why do you think these changes occur?

2. In order to lead into the power of models, ask the students to explain the following in more abstract and complex terms:
   - “Where does the rain go after it falls? How does the water get back into the sky so it can rain another day? Since we can’t see evaporation, even if we watch for hours, how can we explain it? How could we draw this cycle of water? What could we build?”
   - “Why can’t we see the Sun at night? What could we do to explain this to someone? Since we can’t go into space and look down on the Earth and Sun, what could we build to help explain the rising and setting of the Sun?

3. You can conclude that a model can be used to help explain these phenomena. Ask the students why a model is good in such cases. For the water cycle, they may say that the process takes too long to observe, or is a process not easily seen. For the day-to-night cycle of the Sun, they may say these objects are too big to observe or it’s too hard to leave Earth and look back.

Part 2) Define and Identify Models

Preparation & Procedures

1. Show and/or have three or four children briefly show models in the classroom (toy car, airplane, stuffed animal, etc.) Ask students to describe a model and what the real object does or is. ("It's a fire engine; it puts out fires.")

2. Question them so they reveal that the object does not actually do the thing for which it is intended; rather, it's just "pretend" or a "model." For the fire engine example, use leading questions such as "What is the purpose of it? Can a person fit inside? Does the engine actually work? Could you drive it to the fire? Could it actually put out the fire?" Help them conclude that, "so, since it has wheels and the shape of the real thing, but is much smaller, it must be a model."

3. Ask how they know it's a model ("What are characteristics of the model? Of the real thing?") have the students generate model characteristics. (See *Science Overview* for examples.)

4. Ask students how they would study a dinosaur (which is extinct), an ocean-going ship (which is in the water, usually), or our Solar System (which is incredibly huge). Many students will recognize the difficulty of studying the real objects directly, and may suggest a kind of model instead. (For example, a toy dinosaur, a blueprint of a ship, and photographs of the Sun and planets).

5. If time permits, find a model in the classroom and do a quick "I spy" game. ("I spy a model of something brown and fuzzy with a stubby tail, and four big paws. It's a teddy bear!") Explain briefly why the identified object is a model. Wonder out loud if there are any more models in the room (for example, globes, wall maps, bar charts, photographs).

Teaching Tip

Keep a list of the students' answers, especially their misconceptions. They may use non-relevant details such as size (i.e., a small object is not necessarily a model just because it is small) or they may give incorrect reasons such as color (i.e., a red object is not necessarily a model of another red object.) Use these misconceptions to refine your teaching points.

Teaching Tip

During "I spy," remind students that

- A model can show us patterns and cycles that happen so slowly or quickly as to be almost invisible to us (e.g., a model of the water cycle, the beating of a hummingbird's wings as seen in a photograph of a hummingbird in flight).
- A model can show us how things work that are too far away to see (the Alaska pipeline, a weather satellite).

Part 3) Build a Popsicle Model of a Cycle

Preparation & Procedures

1. Place popsicle sticks, 3"x5" note cards or colored paper, and tape at workstations.

2. Ask students how they would build a model to represent one of the patterns or cycles with which they are familiar. Tell them the limitation is that they can use only simple classroom materials and popsicle sticks.

> **Teaching Tip**
>
> This works well both as an independent project or group activity.

3. If desired, show the students a sample of a model you could make (see *Teacher Fact Sheet* for examples). Explain how the use of arrows in a model can indicate the change to the next stage in a cycle.

4. Tell the students to choose one of the natural patterns or cycles that has been discussed, because they will be making a model of it. They must choose what to build before they begin.

5. Have the students sketch out their ideas on a scratch sheet of paper before they begin to glue popsicle sticks together, or to attach note cards to the sticks. Some students will generate a list; others will make a rough drawing of their planned model.

> **Teaching Tip**
>
> This project can easily be completed as homework.

6. As you circulate around the room, ask them leading questions such as "Does this part of the cycle happen before or after that one?" or "Does anything happen in between these two parts of the cycle?"

7. Have students complete their projects before moving on.

> **Lesson Adaptation**
>
> *Talented and Gifted:* For homework, have the students build models of other (difficult or impossible to see) processes using any materials they may find around the house. The materials may actually represent part of the process, or simply be useful in illustrating the process.

Curriculum Connections

- *Mathematics:* Make graphs and charts, equations, and other numeric representations of familiar data or phenomena. Those are mathematical models.
- *Art:* Design 2-D and 3-D physical models of natural phenomena easily on a scale we can handle.

Reflection & Discussion

- Have some students show their models, and tell the class how actually making a model is important to understand the pattern or cycle it represents. The students conduct the discussion as much as possible.

- Make sure to discuss as a class any models they built relating to astronomical cycles (e.g., rising and setting of the Sun, Moon, and planets; the seasons; daily and annual changes in temperature and weather).

Transfer of Knowledge

Help students begin to understand the value of models for studying astronomical cycles and objects in the sky.

1. If students in the class did not design models of astronomical cycles, design at least one such model as a class.

2. Ask, "What do you see when you look up in the sky at night?" (Moon, stars, meteors, planets, comets). If available, show 3-D models or photos.

3. Discuss the Sun and its family of planets.

4. Ask students to imagine themselves on other planets like Mercury or Mars. Have them describe cycles such as sunrise and sunset, and daily changes in temperature based on what they know of the planets.

Placing the Activity Within the Lesson

Point out to students that by building a model of a process, pattern, or cycle that is difficult or impossible to see, they will begin to understand how we can explore different phenomena, not only on Earth, but elsewhere.

Have students discuss why a model is sometimes much better than the real thing (for example: it shortens the time the real process takes; it's safer). Have the students hypothesize as to why a model may not always be as good as the real thing (for example: it won't work; you can't ride it; it doesn't behave the same way).

Assessment Criteria for Activity 1

Grades 3-4 students may be evaluated as follows. They need not demonstrate all the characteristics of a category to fall within it, though strong evidence of their classification by the teacher should be provided.

4 Points

- Clearly and consistently demonstrates a sophisticated understanding of the concepts nearly 100% of the time by applying them accurately in activities, questions, comments, work, and projects both in the classroom and elsewhere.

3 Points

- Shows a nearly complete grasp of the concepts by using them appropriately at least 75% of the time in class, asking pertinent questions, and by making viable attempts at applying the concepts to other aspects of learning.

2 Points

- Responds correctly to direct questions regarding the meaning of the concepts, but cannot yet express them or demonstrate them consistently and accurately; still makes errors about 50% of the time.

1 Point

- Indicates little more than random guessing at understanding the concepts; cannot focus on essential elements or regularly respond correctly to leading questions; less than 50% accurate.

0 Points

- No work completed.

Lesson Wrap-Up

Lesson Closure

Label the models as to what they represent, and hang them from the ceiling or walls so that the other students can look at them more closely.

Have the class discuss all their models and see if there are any common themes like

- models that describe life cycles, or
- models that describe astronomical phenomena.

Notes on Activity:

Resources

Internet Resources & References

Student-Friendly Web Sites:

Kids Astronomy
    www.kidsastronomy.com/solar_system.htm
NASA Kids' Club
    www.nasa.gov/audience/forkids/kidsclub/flash/
NASA's Planetary Photojournal
    photojournal.jpl.nasa.gov

Teacher-Oriented Web Sites:

American Association for the Advancement of Science, Project 2061 Benchmarks
    www.project2061.org/tools/benchol/bolintro.htm
Exploring Planets in the Classroom
    www.spacegrant.hawaii.edu/class_acts/
NASA Quest
    quest.arc.nasa.gov/sso/teachers/
National Science Education Standards
    www.nap.edu/html/nses/
The Nine Planets
    www.nineplanets.org
Voyage: A Journey through Our Solar System
    www.voyagesolarsystem.org
Journey through the Universe
    www.journeythroughtheuniverse.org

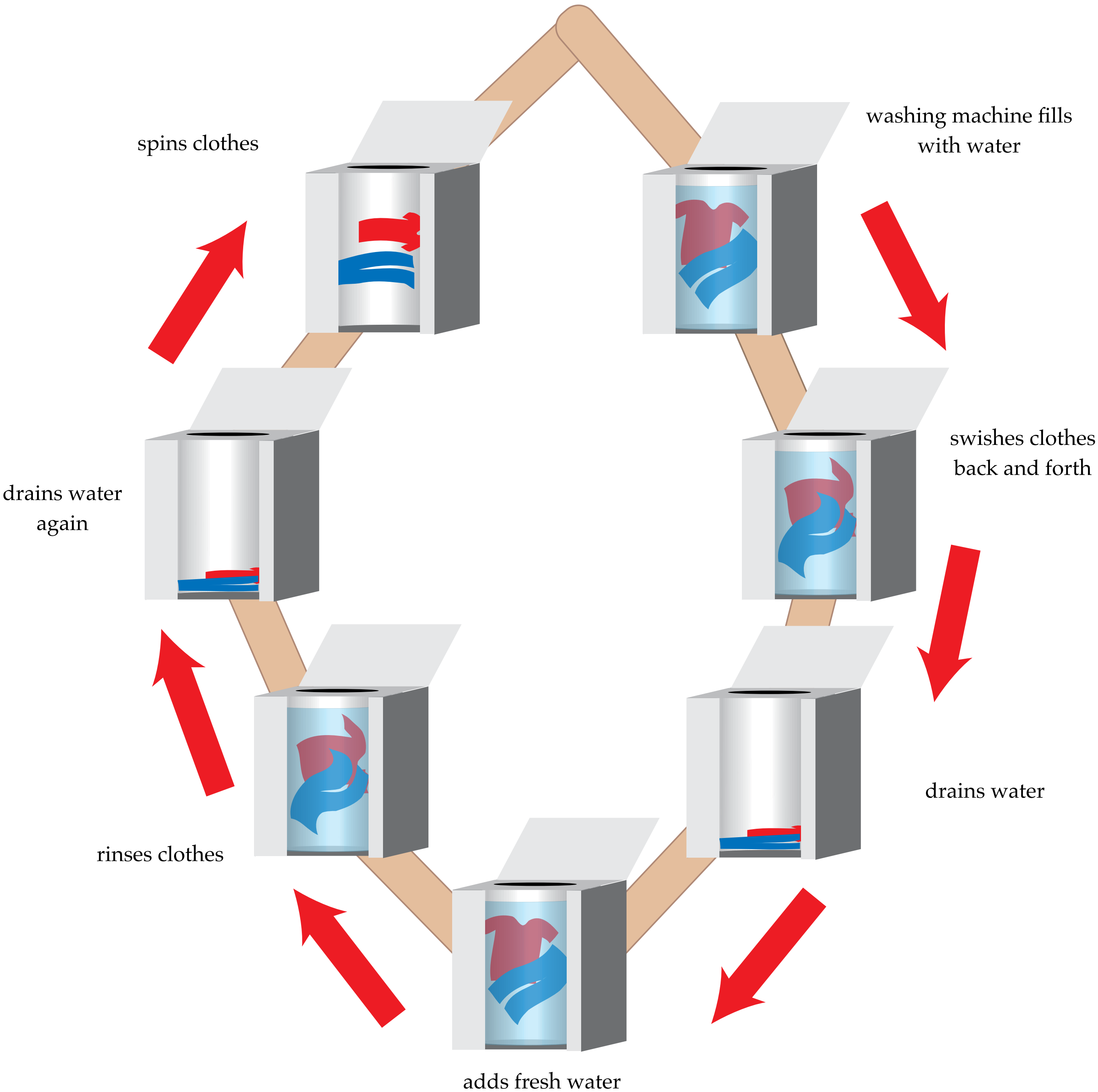
Other Resources

Asimov, Isaac. *Library of the Universe* series of books on space
Graham, Ian. *My Book of Space*
Rabe, Tish. *There's No Place Like Space! A Dr. Seuss book*
Ross & Moore. *Earth Cycles*

Notes:

Teacher Fact Sheet

Sample popsicle stick model of a cycle



This represents a cycle with which the students will be very familiar, and which they can explore at home. Remind them that they must build *their* popsicle stick model of a cycle that appears in nature.