Scale from the Solar System to a Monster Bee

Summary

This activity will help students learn about the importance of scale - from the distance to the moon to the size of a dung beetle.

Materials

MicroCosmos DVD
Marbles (1 cm)
Metric rulers
Calculators
Various round objects (diameters of 0.5 cm, 0.25 cm, 0.1 cm)
Yellow beach ball (20 cm)
A variety sizes of nuts and seeds
Pinheads
Heavy construction paper
Paper
Tape

- *Dr. Art's Guide to Science*

Additional Resources

Books

- *Dr. Art's Guide to Science: Connecting Atoms, Galaxies, and Everything in Between*, by Art Sussman; ISBN 0-7879-8326-8
- *The Exploratorium Guide to Scale and Structure: Activities for the Elementary Classroom*, by Barry Kluger-Bell and the School in the Exploratorium, ISBN 0-435-08372-4.

Videos

- *The Films of Charles & Ray Eames -- The Powers of Ten*, by Image Entertainment, ASIN 6305943877
- *MicroCosmos*, by Miramax, ISBN 0-7888-5091-1

Background for Teachers

Scale is the Grade 6 science theme. We exist somewhere in an awesome reality that expands many powers of ten above us and submerges many powers of ten below us. At our level of reality, we cannot draw or make a picture of objects such as a bacterium or a planet at its real size. We have to adjust the scale in order to visualize the object and its parts. Describing the scale of very small and very large objects requires using exponents.

While scale can help us visualize the world of the very small and the very large, some things in which we are interested, such as the solar system, pose challenges. Because the Sun is so much larger than the planets, we cannot draw the sizes of the Sun and its planets correctly to scale on the same piece of paper. Any scale that we use to draw the planets will not be compatible with showing how far apart they are. We need a different kind of model to correctly scale the objects in the solar system and their distances from the Sun. We also need different units, such as the light year, to describe the incredibly large distances of the Milky Way galaxy and the universe.

Learning about scale is important because things can change in very surprising ways in going from one level of size to another. In the early 1900s, physicists went crazy because they kept trying to understand electrons and protons based on how things behave on our level of reality. It turns out that electrons and protons are incredibly different from anything we experience. The changes in scale that

we investigate may not manifest such profound changes, but we should always be aware that whole systems are often very different than their parts. Even exactly the same system can appear very different when examined at different scales of perception.

Intended Learning Outcomes

1. Use Science Process and Thinking Skills.
2. Communicate Effectively Using Science Language and Reasoning.

Instructional Procedures

Invitation to Learn

Discuss the following prompt after viewing the dung beetle movie. What thoughts about scale do you have after watching the heroic struggle of the dung beetle?

Instructional Procedures

Ponder a dung beetle's heroic struggle.

Scale both size and distance in modeling Earth and the Moon.

Create a scale model of the solar system that uses the same scale for the sizes of the planets and the distances within the solar system.

Explore the use of light years as a measure of distance, and compare it with other distance measurements that combine speed and time (such as crawling seconds or bicycle hours).

5. Dina the Monster Bee
   illustrates how changing scale can cause unexpected changes.
   Learn about the book you received, *Dr. Art's Guide to Science*, and how it relates to the Grade 6 Science Core.

Extensions

Curriculum Extensions/Adaptations/Integration

Have students make scale models of very large and very small objects. Instruct them to mathematically describe the scale they are using, and to use that scale consistently.

Develop and share different units (such as running minutes) within the school, from the school to home, and from the school to another state or country.

Have students make a specific kind of structure using newspaper. Construct the same structure using the same materials at a scale ten times smaller. Construct the same structure using the same materials at a scale ten times larger than the original. Discuss how the structures and construction process changed at the different scales. See the "Scaled Newspaper Structures" activity.

Family Connections

Make models using other materials at three different construction scales (see *The Exploratorium Guide to Scale and Structure Part III* for ideas).

Develop and share different units (such as running hours) to describe distances such as from home to a store, to a person in another city, to the capital of a foreign country, or to anything that you collectively choose.

Watch the *MicroCosmos* DVD and note how changing scale influences our perceptions, and also changes how life interacts with the physical environment. (Caution: DVD includes scenes of insects mating.)

Assessment Plan

Show students the typical pictorial drawing of the solar system where the planets are correctly to scale with each other with respect to size, but not to scale with the Sun with respect to size, and totally out of scale with respect to distances. Ask them to write one feature that is correct with

respect to scale, and two features that are not accurate with respect to scale.
Show students a model of a toy car crossing a toy bridge over a toy creek. Say that the real car and the real creek are both 500 times larger than the model. If the real bridge were exactly the same as the model except 500 times larger, ask if they would be comfortable driving the car across the bridge. Have them justify their response.
Have students state which of the following distances are best described in terms of kilometers, light seconds, and light years: distance from Earth to the Moon; distance from Earth to the Sun; distance from Earth to the nearest star; distance from Earth to the edge of the Milky Way; distance from Earth to the nearest neighboring galaxy.

Bibliography

Research Basis

Pang, J., & Good, R. (2000). A review of the integration of science and mathematics: implications for further research. *School science and mathematics*, Volume 100 (February), p. 73.
Hurley, M. M. (2001). Reviewing integrated science and mathematics: the search for evidence and definitions from new perspectives. *School science and mathematics*, Volume 101 (May),p. 259.
Teaching about and using concepts of scale inherently involves both mathematics and science. Integrating mathematics and science education attracts many educators, has some obvious benefits, but also conflicting interpretations, and a weak research base.

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