Modeling and Representation in 3-D

grades 6–8

Objective

Students will learn about observation, representation, perspective and modeling by working up from two-dimensional perspective drawings to constructing and examining three-dimensional models.

Introduction

One of the things that scientists do is to build descriptions and understandings of the way the world around us works that allow us to make useful predictions. These descriptions are called "models". Models can take many forms. Some models are mathematical formulas, like those used to calculate acceleration or velocity. Some models are graphic descriptions of how the pieces of something are arranged or how they interact, such as the various models for atoms. Other models take the form of small scale versions or physical constructions that approximate some, but not all, of the elements of the original object or event.

To build useful models, scientists must use skills that students can use, too — skills of observation and representation. Observational skills are **ways of looking**. Scientists have to find ways to look at objects carefully and purposefully, to notice and record as much information as possible. They need this information to build models that look and feel like the original objects. Representational skills are **ways of picturing.** Scientists must find ways to draw, sculpt, build or program their models so that those models accurately depict the original objects. Looking at the model must be almost as good as seeing the real thing.

In this activity, students will practice first looking at and then picturing an object, with special attention to the dimension of perspective — the way that objects appear to the eye, in terms of their particular position, their distance from us, and their placement in relation to other objects. Understanding perspective is crucial to students or scientists trying to build complex models depicting multiple objects and the relationships between them.

Once they have observed and pictured an object in two dimensions, students will practice turning those two-dimensional representations into a three-dimensional model. Finally, they will see how astronomers have used two-dimensional representations to build a virtual three-dimensional model that allows them to explore the galaxy.

Requirement

The American Museum of Natural History's "Digital Universe" program, including the Partiview software and Milky Way Atlas data set. The software can be downloaded at http://www.haydenplanetarium.org/hp/vo/du/index.html.

Additional Materials

Modeling_in_3-D file
Pen and drawing paper
An object to draw (e.g. a teapot)
Tape
A beachball, cardboard box, or other medium-sized, lightweight object (optional) to which you can tape students' drawings to create a three-dimensional model (see step 13)
LCD projector (optional)

Additional Resources for Educators

Other astronomy activities are available in the "Resources for Learning" section of the American Museum of Natural History Website:
http://www.amnh.org/education/resources/index.html

Procedure

Part One: Rendering Perspective in Two Dimensions

1] Seat students in groups at tables (or clusters of desks) distributed evenly throughout the room.

2] Place an object in the center of the room so that it is easily visible to everyone in the class. The object should be something with a complex, somewhat asymmetrical shape (such as a teapot) that will look different from different angles.

3] Pass out drawing paper (for the purposes of the exercise, all students need to be using the same size and type of paper).

4] Give students 5 to 10 minutes to draw the object *as they see it from where they are sitting*.
Explain: The idea is not to draw a perfect teapot, but to faithfully represent what you are seeing from where you're sitting right now. Try to draw the teapot in such a way that someone looking at your drawing would be able to guess where you were sitting in the room. If you want, you can represent other objects that are behind (in the background) or in front of (in the foreground) the teapot, to help orient the viewer. You can also draw shadows or other lighting effects.

5] When you are done with your drawings, confer with the other members in your group and choose the drawing from your table that best represents the view from that angle — the one you think gives the most or best clues to the artist's location relative to the teapot. [Depending on the size of your class and the number of groups, and if it makes sense to have a larger pool of drawings, you can have the groups choose the two or three best drawings.]
Explain: While you're deciding which drawing is best, think (and talk amongst yourselves) about what kinds of visual clues each of the artists in your group used to indicate their position in relation to the teapot.

6] Collect the chosen drawing from each student group and shuffle the stack.

7] Choose a student from each group to come to the center of the room, pick a drawing from the pile, and then try to figure out where that drawing originated. The student should walk around the room, stand at each table and compare the view to the drawing she is holding. **Ask:** While you are trying to figure it out, talk aloud to the rest of the class about what you are seeing. What clues or details in the drawing help you eliminate some possibilities?

8] After each correct or incorrect guess, discuss the clues in the drawing: the artist who made the drawing should explain what (s)he did to convey his/her perspective, and the student who made the guess can explain what clues helped her figure out where the drawing was made. **Ask**: In drawings that effectively convey their perspective, what elements of the object are shown and what are hidden? How does the placement of other objects in the background or foreground reveal the artist's perspective? What other techniques do students use to give a sense of where the artist is in relation to the object?

9] When you have gone through all of the drawings in the stack, have students return to their seats.

10] As a class, generate a list of tricks or techniques that artists use to successfully depict their perspective.
Explain: One word for the thing we've been practicing and discussing in this activity is "perspective." The word "perspective" means the way objects appear to the eye — in terms of their particular position, their distance from us, and their placement in relation to other objects. You can also use the word "perspective" to describe the ways an artist tries to represent, on a piece of paper, the way the world looks in three dimensions.

Part Two: Creating a Three-Dimensional View

11] Choose one of the most successful of the student drawings and show it to the class for further consideration.
Explain: So far we've each tried to use one drawing on one piece of paper to show what a three-dimensional object really looks like. We all agree that this drawing, for example, does a pretty good job of showing what the teapot looks like from where [the artist] is sitting.
Ask: Is there anything missing from this drawing? If I wanted to know what the *whole* teapot looks like, from anywhere in the room, would this drawing be sufficient? What *can't* I see in this drawing? Is there a way that we (the class) can use our drawings to make a model that shows all perspectives on an object? Can we use two-dimensional images to create a three-dimensional view of something?

12] Lead the class towards conceiving a construction that makes a box (or other many-sided figure) out of their drawings — a three-dimensional shape with a different "view" of the teapot on each side.

13] If necessary, give students a chance to make additional drawings of the teapot — from above or below, for example – to create a complete rendering of the teapot.

14] Assemble the drawings into a box with tape [drawings could also be taped to the outside of a beachball or a cardboard box]. Pass the model around or allow students to walk around it. **Ask and Discuss:** Is this model of the teapot two-dimensional or three-dimensional? **Explain:** Notice how the three-dimensionality of the model is limited by the number of views we were able to make.
Ask: What if we had a hundred drawings of the teapot, each from a different angle? A thousand? What does this model give you that a single drawing does not?

15] Now run the Digital Universe software (ideally connected to an LCD projector) and view a computer rendering of a three-dimensional teapot by opening the file named Modeling_in_3-D. Rotate the image so the digital teapot is spinning. Fly towards or away from the object to show the model from different distances.
Ask: Is this model of a teapot two-dimensional or three-dimensional?
Explain: This is a three-dimensional model. One of the advantages of digital modeling is that it allows you to build a three-dimensional model, even though the representation of the model can only be done in two dimensions. A mathematical three-dimensional model within the computer is translated to perspective representations that show the three-dimensional nature of the object even on a two-dimensional screen.

16] Now introduce the Digital Universe model of the Milky Way by opening the main **Milky Way Atlas** file and turning on the "stars" data set. Starting on the Sun, back away from the Sun and then orbit around it. Pulling back farther from the Sun reveals more and more of the entire galaxy. Turn on the extrasolar planets data set [expl], and backing out of the cluster of exoplanets around the Sun, explain that these are nearby stars with orbiting planets.
Ask: Is this model two-dimensional or three-dimensional? What about this model is similar to the class's model of a teapot? What is different? What does a model like this allow you to do?

Relevant Standards

From Principles and Standards for School Mathematics: Math Content Standards: 6–8

Instructional programs should enable all students to:

- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them (Data Analysis and Probability)
- create and use representations to organize, record, and communicate mathematical ideas (Representation Standard for Grades 6–8)
- select, apply, and translate among mathematical representations to solve problems;
- use representations to model and interpret physical, social, and mathematical phenomena.

From the National Science Education Standards: Science Content Standards: 5-8

Content Standard A: Science as inquiry.
As a result of activities in grades 9–12, all students should develop: abilities necessary to do scientific inquiry; understandings about scientific inquiry…. Fundamental abilities and concepts that underlie this standard include:

- [Ability to] use appropriate tools and techniques to gather, analyze and interpret data.

- [Ability to] develop descriptions, explanations, predictions and models using evidence.

Understandings about scientific inquiry

- Different kinds of questions suggest different kinds of scientific investigations.
- Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.

Content Standard G: History and nature of science.

As a result of activities in grades 5–8, all students should develop understanding of: science as a human endeavor; nature of science; history of science…. Fundamental abilities and concepts that underlie this standard include:

- Nature of science: Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models ….
- It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists….

Credit: This material is based upon work supported by the National Aeronautics and Space Administration under Grant No. NAG5-11139: The Partnership between NASA and the American Museum of Natural History: Furthering Our Joint Educational Mission.