Session 1 – Modelling the Universe

General Description

Students are challenged to create a model of the Universe. This is an introductory activity that helps students think about where we fit in the Universe, and allows them to model the size, shape, and relative position of objects in the Universe. The activity has three major steps: discussion, modelling, and sharing models with the group. Students can work in groups of 3 or 4. This activity can also be done in pairs if the overall group is small.

Objectives

- To draw out the students' mental model of the structure of the Universe.
- To use the context of space science exploration of the structure of the Universe to help students reflect on the nature of models, evidence, and explanation in science.

Concepts Addressed

- Strengths and weaknesses of models
- Astronomical size and scale
- Earth's physical place in the solar system and Universe

Materials

- Copy of *Universe Model Analysis Student Worksheet* for each group of students (included in Appendix E)
- Examples of models (toy car, doll or action figure, paper airplane, map, etc.)
- A variety of crayons/colored pencils/markers
- 8.5″ × 11″ white paper — one sheet per student
- Model construction supplies — anything you have available that seems appropriate (some examples: construction paper, balloons, balls of different sizes, popsicle sticks, marbles, string, straws, toothpicks, pipe cleaners, pasta, beans)
- Large sheet of sturdy paper on which students create their models — one per group
- Scissors, glue, and tape
- (Optional) Clay or Play-Doh

Other Requirements

- Enough table or floor space for several groups of students to work together on their models

Background

A model is a simplified imitation of something that is used to better understand or work with it. Models can take different forms, including physical devices or sculpture, drawings or plans, conceptual analogies, mathematical equations, and computer simulations.

Models serve many different purposes in astronomy and other fields. A model can make something large more portable and accessible, such as representing the Earth with a tabletop globe. Models can also make something small easier to see and manipulate, such as a model of a tiny cell or DNA. And some models are the same size as the original object, used for testing or display purposes.

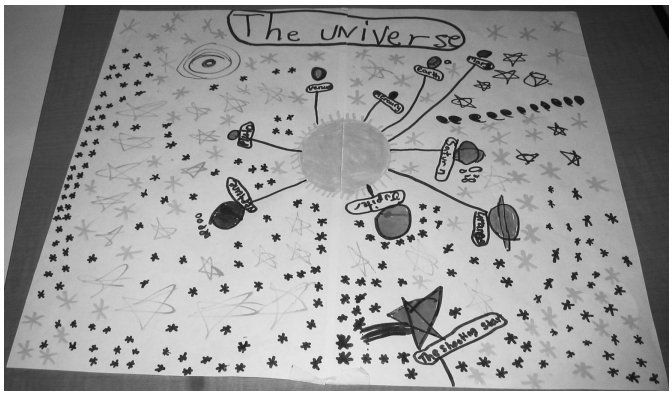
Models can be "to scale," which means that they accurately represent the proportions of an actual object. The scale model can be smaller, larger, or the same size as the original object, but the proportions must be accurate. Some models are not to scale, and do not accurately reflect the actual proportions of the original. These models can be useful when it is difficult to create a scale model, or an accurate scale model is not needed.

Session Overview

As a warm-up, students make a quick model (drawing) of something in their lives. This introduces the concept of modelling.

Students then make physical models to represent as much of the Universe as they can. They then analyze their own and others' models with regard to what they represent, what they misrepresent, what they omit, and what questions they raise.

While the idea of creating a physical model of the entire Universe can seem overwhelming, this activity quickly reveals students' ideas and preconceptions. Most students are somewhat familiar with solar system objects but may be confused about, for example, the relationship of stars to planets and the relative distances between them. The overall organization and structure of the Universe is not well known to most.



An example of a student group's model, depicting a variety of objects, and showing stars mixed in throughout the solar system.

Students should not be corrected in any way during this session, as this is intended to determine the current state of their understanding for later evaluation.

Preparation

- Make copies of the *Universe Model Analysis Student Worksheet* for each group
- Set out all listed materials equally among the groups

Activity

I. Warm-up (10 minutes)

Instruct students to individually make a quick model of something in their lives, using the white paper and crayons/colored pencils/markers available. Allow about five minutes for students to complete these drawings. Alternatively, if you think clay or Play-Doh will make this task clearer to the students, you might consider providing those materials instead of the two-dimensional paper. Students may be more comfortable with the idea of models in three-dimensions.

A toy airplane, one example of a model for participants to consider.

Ask students to identify some models in their lives, such as toy cars, dolls and action figures, models made for school assignments, model airplanes, maps, etc. It is helpful to have a couple of these examples to show during this discussion. Introduce the idea of scale – models that accurately reflect the proportions of the original object. Are the models you have discussed to scale or not to scale? Why is scale important? When does and doesn't it matter to a model? If you have sufficient example models to put one on each table, you can use these as a good starting point for this discussion.

Ask a few students to share their warm-up drawings. Are these models to scale or not to scale? Tell students to keep these ideas about models and scale in mind during the next activity.

II. Discussion (10 minutes)

Facilitate a group discussion of what models are and what they are used for. Discuss how scientists use models to help them think about how things work, and to make predictions. Ask students to name some familiar models (e.g., globe, dollhouse) and lead a discussion on whether these models are exactly like the real thing. Stress that a model is not the real thing, it is usually a simplified or modified version so it can possibly misrepresent features of the real thing. Make sure they understand that models can be two-dimensional as well as three-dimensional.

Lead an open discussion about what is **in** the Universe, and what the Universe **is**. You should leave this discussion fairly short, because their project should reflect their own introductory ideas. The models around the room may end up quite different, and this is entirely acceptable. The more of a discussion you have with the students beforehand, the more likely their models will reflect this discussion rather than their own concepts.

III. Modelling (20 minutes)

(Adapted with permission from the Cosmic Questions Educator's Guide)

1. Divide students into small groups. Groups should decide among themselves who will fill the roles of Recorder of Model Features, and Spokesperson. Students may have more than one role, but all three must be filled.

2. Ask the students to write their names on both the model they create and their worksheet.

3. With the materials in front of them, challenge students to create a model of the Universe in 20 minutes.

   Tell students they should have an explanation as to why they put objects where they do, regardless of the fact that ***they are not required or expected to have all of the scientifically correct answers!***

4. It is important to go around and help with the group dynamics in this activity. All members of the groups should be contributing ideas instead of letting one member give all of the "answers." ***Remember, students should not be corrected in any way during this session, as this is intended to determine the current state of their understanding for later evaluation.***

5. As they work, the Recorder in each group should use the Universe Model Analysis Student Worksheet to list information about the features of their model, and any questions or other thoughts that arise on this topic.

Participants hard at work on their models of the Universe.

IV. Sharing models with the group (15-20 minutes)

Now, ask the spokesperson in each group to present their model. As they do so, ask them to comment on these four questions:

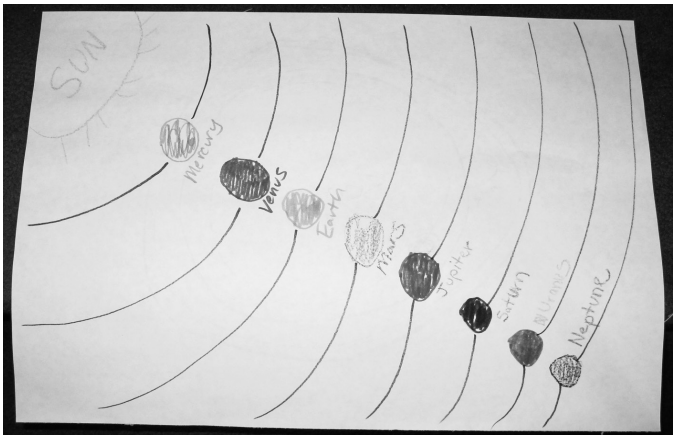
- What features of the Universe does your model represent?

- What things — that you know of — does your model misrepresent?
- What things — that you know of — does your model omit, or not represent at all?
- What questions came up as your group worked on your model?

Use the following questions with the whole group to further probe students' understanding of their models:

- Do you see any patterns?
- Which parts of the models do you think represent the "real thing" particularly well? Why?
- Which parts of the models do you think misrepresented the "real thing"?
- Are these models to scale or not to scale? Why?
- Why is making a model of the whole Universe so difficult?
- How can these models be used to predict what might happen in the Universe?
- What would an observer on Earth see if they lived in this Universe? (Where is Earth in your model?)
- What would you need to know to design a better model?

At the end of the activity, ***collect and save the models (or take a digital photo of them)***. They will be used in concert with the final session to evaluate student progress. You can even tell the students that they will be repeating this activity at the end of the program, and will be able to see how their ideas have changed over time.



A typical model of the Universe, depicting only the Solar System.

Suggestions for Running this Session

- Modelling the entire Universe may seem like a daunting task, but remember, there is no right or wrong answer. The purpose of this activity is to see what their current views are and to get them started thinking about the topic.

- Everyone needs to contribute in this activity. Depending on your group, you may need to work to facilitate this, because sometimes it can be very easy for one or two group members to take over for everybody. If this is a problem with your group, you might consider having the groups go around in a circle and have each member say one idea in turn, or directly ask other members of that group what they'd like to contribute. Balanced group dynamics can be especially difficult if this is the first time these students have worked together.

- Allow students to take over as much of the discussions as possible, trying not to lead or discourage them in any way except to ensure that all members of the groups are participating.

- The materials provided for this activity often have an impact on the models made by students. If you give the group 9 or 10 round objects, they will likely immediately think of planets and possibly not think any further. Keep this in mind as you choose your materials. For consistency, provide the same materials in Session 1 and the repeated modelling activity in Session 12.

- There are many different possible craft supplies that can be used for this activity. Some of the ones we have used in the past include:
  - construction paper
  - chenille stems
  - colorful straws
  - pom poms
  - glitter (not recommended unless you want glitter everywhere for months to come)
  - feathers (almost as bad as glitter!)
  - balloons
  - rubber bands
  - macaroni
  - dried beans

  If you choose to provide food for use in the models, consider how long you'll be keeping the model around. We like to compare the models from Session 1 with the models from Session 12, but some food materials will decay or attract pests if you keep the models around.

- Sometimes participants will want to incorporate other objects into their models (their own possessions, or other materials available in the room). It is up to you whether you permit this, and again, consider how long you'll be keeping that model. It is inconvenient if your tape measures or crayons are taped to a model when you want to use them for other activities!

- To engage students in discussion as models are presented, consider taking them on a "gallery walk" to see other groups' models. All students can gather around each model to see it as its creators explain it.

- If you feel your students need it, you may have them brainstorm a list of objects in the Universe that can be viewed with a telescope, and write these objects on a blackboard or flip chart. Ask what they know about each one as they are offered. Remember that doing this will probably ensure that each group will try to put all objects on the list into their model, regardless of whether they would have thought of this on their own or not.

Useful websites for background or activity extension

- **NASA's Universe Education Forum**
  Answers to questions about the structure and evolution of the Universe are available at this site.
  http://www.cfa.harvard.edu/seuforum/questions/

  – Extensive learning resources for investigations of the Universe
    http://www.cfa.harvard.edu/seuforum/learningresources.htm

  – *Cosmic Questions Educator's Guide*
    http://www.cfa.harvard.edu/seuforum/download/CQEdGuide.pdf

- ***Cosmic Distance Scale***
  This feature gives a feeling for how immense our Universe is, starting with an image of the Earth and then zooming out to the furthest visible reaches of our Universe — as in the "Power of 10" films.
  http://heasarc.gsfc.nasa.gov/docs/cosmic/

- ***Bad Astronomy* — Astronomy misconceptions explained**
  A great site to deal with questions about the accuracy of "science" encountered in the movies, news, books, or TV. In addition to science explanations at an easy-to-read level, topics are presented in a fun way. The site contains a blog and a bulletin board for questions.
  http://www.badastronomy.com/