Solar System Bead Distance Activity

Introduction:
Our solar system is immense in size. We think of the planets as revolving around the sun but rarely consider how far each planet is from the sun or from each other. Furthermore, we fail to appreciate the even greater distances to the other stars. Astronomers refer to the distance from the sun to the Earth as one “astronomical unit” or AU. This unit provides an easy way to calculate the distances of the other planets from the sun and build a scale model with the correct relative distances.

Instructional Objective:
By calculation and through the construction of a scale model solar system (based on their calculations where age-appropriate), students will observe the relative distances of the planets, the asteroid belt and dwarf planet Pluto from each other and the sun including the increasingly vast distance spacings of planets in the outer solar system compared to the inner solar system.

National Science Education Standards:
Standard D: Earth in the Solar System
National Math Education Standards:
NM.5-8.5 Number Relationships
NM.5-8.13 Measurement

Vocabulary:
Astronomical Unit - 1AU = approximately 150 million kilometers (93 million miles)
(149,597,870,700 kilometers or 92,955,807,238 miles to be exact!)

Activity:
We will construct a distance model of the solar system to scale, using colored beads as planets. The chart below shows the planets and asteroid belt in order along with their distance from the sun in astronomical units. First, complete the chart by multiplying each AU distance by our scale factor of 10 centimeters per astronomical unit. Next, use the new distance to construct a scale model of our solar system. Start your model by cutting a 4.5 meter piece of string (5.0 meters if you are doing the Pluto extension). Use the distances in centimeters that you have calculated in the chart below to measure the distance from the sun on the string to the appropriate planet and tie the colored bead in place. When you are finished, wrap your string solar system around the cardboard holder. Note that the bead colors are rough approximations of the colors of the planets and the sun,

Keep two important solar system facts in mind. The first is that the planets **never** ever align in a straight line. Occasionally skywatchers are treated to the sight of two bright planets apparently close together as viewed from our planet.

The second fact is that your string solar system is a **radius** of the orbits of the planets. To see how large the solar system is hold the sun in one location and swing the planets in a circle around it. If you move counter-clockwise you will be moving the planets in the direction

they move as viewed from above their plane. The whole circumference of the solar system probably will not fit into your classroom.

Planet	AU	Scale Value (cm)	Color
Sun	0.0AU	____0__cm	yellow
Mercury	0.4AU	_____cm	solid red
Venus	0.7AU	_____cm	cream
Earth	1.0AU	___10__cm	clear blue
Mars	1.5AU	_____cm	clear red
Asteroid belt	2.8AU	_____cm	black
Jupiter	5.2AU	_____cm	orange
Saturn	9.6AU	_____cm	clear gold
Uranus	19.2AU	_____cm	dark blue
Neptune	30.0AU	_____cm	light blue
* Pluto (closest)	29.7AU	_____cm	brown
Pluto (average)	39.5AU	_____cm	brown
* Pluto (most distant)	49.3AU	_____cm	brown

* Extension 1: You can add “dwarf planet” Pluto’s nearest and most distant points to illustrate that Pluto’s orbit is much different than the eight major planets. This was one element of the decision to describe Pluto as a dwarf planet. When Pluto is closest to the sun it is **inside** the orbit of Neptune. If a bead is to be added for Pluto at this point it needs to be on the string before the Neptune bead is tied off. So the order will be: Uranus, Pluto, Neptune, Pluto, Pluto.

Extension 2: Consider that if you were traveling at the speed of light, it would take 8 minutes and 19 seconds (or about 8.3 minutes) to travel from the sun to the Earth (1 AU). Using this measure, students can calculate the light-time from the sun to each planet. It would take 4.3 years (traveling at the speed of light – 300,000 kilometers per **second**) to reach the next nearest star system, Alpha Centauri!

Extension 3: The Voyager spacecraft are the most distant human-made objects. Launched in 1977 the mission flew by all four of the “Jovian” planets -- Jupiter, Saturn, Uranus and Neptune (only Voyager 2 flew past Uranus and Neptune) -- and kept on going. At the start of 2010 Voyager 1 was 111.4AU from the sun, almost four times as distant as Neptune! Each year it moves another 3.5AU farther. Add Voyager 1 by tying additional string on to the end of your solar system.

Materials:

- Planet beads (large craft pony beads in 11 colors) roughly approximating the appearance of the planets and the sun
- Five meters of string for each student
- Small piece of cardboard to wrap solar system string around (10 cm x 10 cm)
- Meter sticks or rulers with centimeter markings for each student or group to share
- Student calculations table, one for each student

Background:

- To speed up the activity for younger students, the string may be pre-cut and a set of solar system beads may be put into a plastic zip-lock bag for teach student. Also, for younger students, a measured marking grid can be put on a table top so the students can mark their measured distances and then tie off the beads. If the pre-marking method is used, extra distance must be added to each planet distance to accommodate the string within each knot (approximately 4 centimeters for a double knot around the bead). Tape newspaper to the surface where the students will be marking their strings so they do not mark up the counter or floor.
- For older students, measurements are made each time from the sun to the planet and tied on after each measurement.

Student Procedure:

1. Convert the various astronomical unit distances to centimeters and complete the chart on the student calculations table.
2. Measure and cut a piece of string 4.5 meters long.
3. Using the calculated centimeter distance, tie the bead onto the string using a double knot.
4. When finished with the activity wrap the solar system string (with beads) around the cardboard holder.

Distance Answer Key:

Planet	AU	Scale Value (cm)	Color
Sun	0.0AU	____0__cm	yellow
Mercury	0.4AU	____4__cm	solid red
Venus	0.7AU	____7__cm	cream
Earth	1.0AU	___10__cm	clear blue
Mars	1.5AU	___15__cm	clear red
Asteroid belt	2.8AU	___28__cm	black
Jupiter	5.2AU	___52__cm	orange
Saturn	9.6AU	___96__cm	clear gold
Uranus	19.2AU	__192__cm	dark blue
Neptune	30.0AU	__300__cm	light blue
* Pluto (closest)	29.7AU	__297__cm	brown
Pluto (average)	39.5AU	__395__cm	brown
* Pluto (most distant)	49.3AU	__493__cm	brown
Voyager 1	111.4AU	_1,114__cm	any color

Credits: Tom Gates – NASA Educator, NASA Ames Research Center. Adapted by Steve Klug, Fees Middle School, Tempe, AZ, Sheri Klug, ASU Mars K-12 Education Program, Tempe, AZ, David Seidel, Jet Propulsion Laboratory, Pasadena, CA.

Student Calculations Table:

Planet	**AU**	**Scale Value (cm)**	**Color**
Sun	0.0AU	____0__cm	yellow
Mercury	0.4AU	_____cm	solid red
Venus	0.7AU	_____cm	cream
Earth	1.0AU	___10__cm	clear blue
Mars	1.5AU	_____cm	clear red
Asteroid belt	2.8AU	_____cm	black
Jupiter	5.2AU	_____cm	orange
Saturn	9.6AU	_____cm	clear gold
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