Solar Size and Distance Modeling

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Astronomy & Space Science
Lesson Implementation Presentation
April 6th, 2021

Lesson Implementation & Purpose

- This lesson was chosen for the 8B science class.
- 100% of students are fully virtual and use Zoom and Google Applications for learning and instruction,
- Students have been virtual for the entire school year, and have chosen to remain virtual until the last day of school in June.
- Class periods in the virtual environment are 75 minutes long.
- Two classes are taught daily by content area teachers.
- Periods 3 & 4 are taught on A Days
- Periods 5 & 8 are taught on B Days

Student Population Data

- Team 8B:
  - 95 students
  - 41 female students; 54 male students
  - 0 students with an active IEP
  - 2 students with medical 504 plans
- Average Science Scores for Physics & Astronomy
  - Period 3: 89%
  - Period 4: 94. 21%
  - Period 5: 91.91%
  - Period 8: 90.57%

Astronomy Unit Understandings

- Unit Enduring Understandings
  a. The universe is made up of many billions of galaxies, each consisting of billions of stars and orbiting these stars are other celestial bodies.
  b. Gravity is the force that organizes the universe and causes objects to move in a regular and predictable motion.
  c. The Sun is a star, and shares its characteristics with other stars. It is the source of all energy on earth.
  d. The earth, sun and moon work as a system that produces seasons, tides, moon phases and day/night. This system also influences climate and weather patterns.
  e. The properties of the bodies in the solar system reveal information about its early history.

Astronomy Unit Standards

- NGSS Standards unit is created around
  - **MS-ESS1-1** Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.
  - **MS-ESS1-2** Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
  - **MS-ESS1-3** Analyze and interpret data to determine scale properties of objects in the solar system.
  - **MS-PS2-4** Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.

Lesson NGSS Science Standards

- NGSS Standards
  - **MS-ESS1-2** Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
  - **MS-ESS1-3** Analyze and interpret data to determine scale properties of objects in the solar system.

Unit Based Lesson Objectives

- **Benchmark Objectives**
  - The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. (MS-ESS1-2),(MS-ESS1-3)
- **Ability Objectives**
  - Analyze and interpret data to determine similarities and differences in findings.
  - Construct an explanation using models or representations.
  - Collect data to produce data to serve as the basis for evidence
- **Daily Objectives**
  - Students will be able to model the scale distance and size of celestial bodies in our solar system.

Formal Lesson Plan

Solar Size and Distance Scale Model	
Unit Title	Astronomy
Subject/Content Area	Middle School Science, Grade 8
Lesson #, Topic, Length	Solar Size and Distance Scale Model, 75 minute Class Period
I. Learning Objectives	
NGSS Science Standards	**MS-ESS1-2** Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. **MS-ESS1-3** Analyze and interpret data to determine scale properties of objects in the solar system.
Learning Objectives	Benchmark Objectives (Curricular Performance Expectations): • The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. (MS-ESS1-2),(MS-ESS1-3) Ability Objectives: • Analyze and interpret data to determine similarities and differences in findings. • Construct an explanation using models or representations. • Collect data to produce data to serve as the basis for evidence Daily Objectives: • SWBAT model the scale distance and size of celestial bodies in our solar system.
Academic Language	Scale, Distance, Kilometers, Sun, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Diameter, Distance, Model
Instructional Materials	• Slides Presentation • Google Sheets • NASA Web Data Resource • Comprehension Questions

II. Procedures		
Instructional Strategies	**Step- by - Step Procedure**	**Time**
	1. Video: Solar System Distance and Size (3 minutes)	

II. Procedures		
Instructional Strategies and Activities	**Step- by - Step Procedure**	**Time**
	1. Video: Solar System Distance and Size (3 minutes) 2. Defining Scale Models: The teacher will discuss scale models with students and discuss the types of models: numerical models, physical models, illustrated models, written models. (2 minutes) 3. Students will follow step-by-step instructions given to teachers to complete the scale size and distance activity. Students will open the google spreadsheet and will input the data from this website. (2 minutes) 4. Students will be placed in breakout rooms and as a group, choose a scale diameter for the Earth. Each calculation for distance and size will be based on this chosen scale diameter. Students will use the equation scale diameter(actual distance)/ actual diameter = scale distance, in order to calculate the scale distance for Earth from the sun. (3 minutes) 5. Then, using the scale diameter and distance of earth, students will use the equation scale planet diameter (x)/ scale Earth diameter = actual planet diameter/actual earth diameter. Students will input the data on the spreadsheet for the diameter of each planet (15 minutes). 6. Students will then use the equation scale diameter (actual distance)/ actual diameter = scale distance to calculate the distance from the sun for each planet. Students would put this data into the spreadsheet for each planet. (15 minutes). 7. When the Google Sheet numerical model of the Solar System is complete, students will participate in a group discussion to answer the following comprehension questions: 1. What diameter of the Earth did you choose for the scale model? 2. What equation did you choose to calculate scale distance from the sun in cm? 3. What equation did you use to calculate the scale diameter of each planet? 4. Are the distances between each planet in your scale model proportional to the actual distances between each planet? Why or why not? If not, how can you adjust/check your calculations? 5. What are the benefits of creating a numerical scale model like this one? 6. How does using both scale size and distance in a model differ from a model that only uses scale size or only distance? (15 minutes) 8. Class Discussion: Students will present their screen and discuss the data they calculated and will reveal the equations they used to calculate diameter and distance. The class will also discuss the comprehension questions on modeling. (5 minutes) 9. Exit Question: If we were to create a scale solar system model with the correct sizes and distances, What city/towns/states/ or regions would this model cover if the sun was located at Community Middle School. (10 minutes)	

IV. Assessment

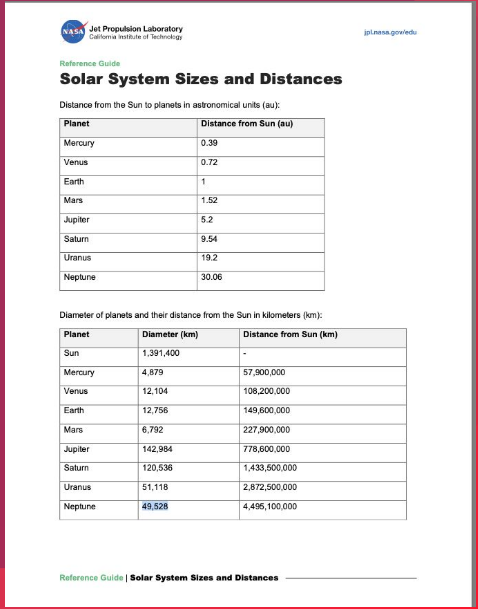
- **Scale Size and Distancing Modeling**
- **Comprehension Discussion Questions**

Links to Instructional Resources

Click image above to view slides presentation

Click image below to watch student engagement video

Click image below to view NASA data resource



Jet Propulsion Laboratory
California Institute of Technology

jpl.nasa.gov/edu

Reference Guide

Solar System Sizes and Distances

Distance from the Sun to planets in astronomical units (au):

Planet	Distance from Sun (au)
Mercury	0.39
Venus	0.72
Earth	1
Mars	1.52
Jupiter	5.2
Saturn	9.54
Uranus	19.2
Neptune	30.06

Diameter of planets and their distance from the Sun in kilometers (km):

Planet	Diameter (km)	Distance from Sun (km)
Sun	1,391,400	-
Mercury	4,879	57,900,000
Venus	12,104	108,200,000
Earth	12,756	149,600,000
Mars	6,792	227,900,000
Jupiter	142,984	778,600,000
Saturn	120,536	1,433,500,000
Uranus	51,118	2,872,500,000
Neptune	49,528	4,495,100,000

Reference Guide | Solar System Sizes and Distances

Links to Student Resources

Unit 3.0 Introduction to Astronomy
Solar System Scale Size & Distance

Directions: Follow the detailed instructions on the slides presentation. Complete the chart below with all question answers and information asked for.

Question	Answer
What diameter of the Earth did you choose for the scale model?	
What equation did you choose to calculate scale distance from the sun in cm?	
What equation did you use to calculate the scale diameter of each planet?	
Are the distances between each planet in your scale model proportional to the actual distances between each planet? Why or why not? If why not, how can you fix your model to be proportional?	
What are the benefits of creating a numerical scale model like this one?	
Discuss Answer with Group: How does using both scale size and distance in a model differ from a model that only uses scale size or distance?	

Scale Distance & Size Activity

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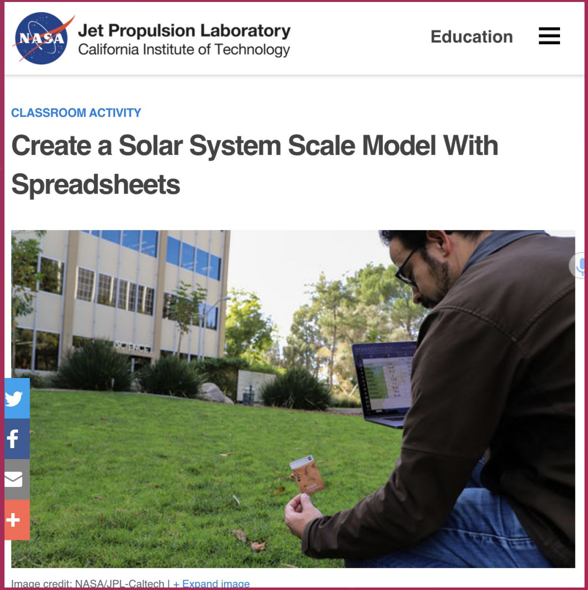
	Scale Diameter (cm)	Scale distance from the sun (cm)	Actual Diameter (km)	Actual Distance from Sun (km)
Sun				
Mercury				
Venus				
Earth				
Mars				
Jupiter				
Saturn				
Uranus				
Neptune				

Where can you find this lesson online?

- Interested in showing your class this lesson?
  - This lesson provided by jpl.nasa.gov includes:
    - Lesson Overview
    - Materials
    - Suggested Background Content
    - Suggested Procedure
    - Discussion Topics
    - Student Assessment
    - Extension Opportunities



Student Work Sample #1

below with all question answers and information asked for.

Question	Answer
What diameter of the Earth did you choose for the scale model?	For our scale model we chose 1 cm for the Earth's Diameter.
What equation did you choose to calculate scale distance from the sun in cm?	The equation for the Distance from the sun is :Scale Planet Diameter/Scale Earth Diameter = Actual Planet Diameter/Actual Earth Diameter
What equation did you use to calculate the scale diameter of each planet?	The equation for the Diameter of each planet is :Scale Distance(Actual Distance)/ Actual Diameter = Scale Distance
Are the distances between each planet in your scale model proportional to the actual distances between each planet? Why or why not? If why not, how can you fix your model to be proportional?	Yes, the distances in the Scale and Actual Models are proportional because the equations we had used to find the scale dimensions were in ratio to the Actual Distance and the Dimensions.Our data for the Earth with into ratio for the actual length as well.
What are the benefits of creating a numerical scale model like this one?	This scale is helpful because it allows scientists who study the solar system to have an accurate understanding and values of the distance and the sizing of each of the planets. Also the scale model is even more helpful because it allows the scientists to visualize the scale in which the planets are laid out at a smaller scale.
Discuss Answer with Group: How does using both scale size and distance in a model differ from a model that only uses scale size or distance?	In order to make an accurate model we must take into account both the Distance and the Size because the size and distance must both be in ratio with the size of the Earth. Also the size could alter the scale model because the size influences the distance, thus we would need both in order to make a proper estimation of the planets.

Student Sample #1 - Scale Distance & Size Acti...

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	A	B	C	D	E
1		Scale Diameter (cm)	Scale distance from the sun (cm)	Actual Diameter (km)	Actual Distance from Sun (km)
2	Sun	n/a		1,391,400	
3	Mercury	0.003506540175	11867.1859	4,879	57,900,000
4	Venus	2.480836237	8939.193655	12,104	108,200,000
5	Earth	1	11727.81436	12,756	149,600,000
6	Mars	33554.18139	1125883089	6,792	227,900,000
7	Jupiter	21.05182568	5445.364516	142,984	778,600,000
8	Saturn	0.843003413	11892.71255	120,536	1,433,500,000
9	Uranus	0.4240890688	56193.51305	51,118	2,872,500,000
10	Neptune	0.9688954967	90758.76272	49,528	4,495,100,000
11					

Student Work Sample #2

below with all question answers and information asked for.

Question	Answer
What diameter of the Earth did you choose for the scale model?	We chose to scale the earth at a diameter of 1 cm.
What equation did you choose to calculate scale distance from the sun in cm?	(Scale Diameter * Actual Distance)/Actual Diameter = Scale Distance is the equation that we used to calculate scale distance from the sun in centimeters.
What equation did you use to calculate the scale diameter of each planet?	We divided their actual diameter by the earth's diameter and used that number since we scaled the Earth at 1 centimeter.
Are the distances between each planet in your scale model proportional to the actual distances between each planet? Why or why not? If why not, how can you fix your model to be proportional?	They are proportional to the actual distances because the greater the distance in the scale model, the greater the actual distance is on the chart.
What are the benefits of creating a numerical scale model like this one?	Creating a numerical scale model like this one helps you be very accurate with scaling. It is important to be very accurate with scaling, otherwise the model will not be on point and will be much different than the expected result.
Discuss Answer with Group: How does using both scale size and distance in a model differ from a model that only uses scale size or distance?	Using both scale size and distance differs because you have multiple variables that are affecting the scaled distance. If you had only one variable, then the amount will only increase and decrease as that single variable increases and decreases.

Student Sample #2- Scale Distance & Size Activity

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	Scale Diameter (cm)	Scale distance from the sun (cm)	Actual Diameter (km)	Actual Distance from Sun (km)
Sun	109.08	[redacted]	1,391,400	[redacted]
Mercury	0.3824866729	4539.040451	4,879	57,900,000
Venus	0.95	8492.233972	12,104	108,200,000
Earth	1	11727.81436	12,756	149,600,000
Mars	0.5325	17867.60159	6,792	227,900,000
Jupiter	11.21	61042.53623	142,984	778,600,000
Saturn	9.45	112386.1336	120,536	1,433,500,000
Uranus	4	224774.0522	51,118	2,872,500,000
Neptune	3.88	352143.9994	49,528	4,495,100,000

Student Work Sample #3

below with all question answers and information asked for.

Question	Answer
What diameter of the Earth did you choose for the scale model?	1.2 cm is what we chose for the scale model.
What equation did you choose to calculate scale distance from the sun in cm?	We chose scale diameter(actual distance)/actual diameter=Scale distance.
What equation did you use to calculate the scale diameter of each planet?	We did scale diameter/scale distance=actual diameter/actual distance.
Are the distances between each planet in your scale model proportional to the actual distances between each planet? Why or why not? If why not, how can you fix your model to be proportional?	The scale distances are pretty proportionate to the actual distance because it is cut down a couple of digits but the digits are similar since we found out the diameter first that is going to give us something close to the actual distance.
What are the benefits of creating a numerical scale model like this one?	The benefits of creating numerical scale models like this one are you can imagine how big the actual solar system would be and the distances if this was a certain time bigger.
Discuss Answer with Group: How does using both scale size and distance in a model differ from a model that only uses scale size or distance?	Using scale size and a scale distance differs from only using one of them because while using both of them it shows the distance in a miniature version but if you only use one either scale size or scale distance it will only help you imagine how one will diffenciate from the actual and plus you won't be able to make a actual size model with the real distances and diameters.

Student Sample #3- Scale Dist

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	Scale Diameter (cm)	Scale distance from the sun (cm)	Actual Diameter (km)	Actual Distance from Sun (km)
Sun	130.89		1,391,400	
Mercury	0.458	5,435.17	4,879	57,900,000
Venus	1.14	10,190.68	12,104	108,200,000
Earth	1.2	14,073	12,756	149,600,000
Mars	0.64	21,474.67	6,792	227,900,000
Jupiter	13.45	73,240.15	142,984	778,600,000
Saturn	11.34	134,836.36	120,536	1,433,500,000
Uranus	4.8	269,728.86	51,118	2,872,500,000
Neptune	4.65	422,028.24	49,528	4,495,100,000

Lesson Strengths

- Students were able to follow directions on the slides.
- Students asked clarifying questions that were then shared with other groups to support equity.

- Students carried out small group discussion in breakout rooms and worked together to check calculations.
- Although students did not have time for the exit question, they were able to check over calculations by dividing the work.

- Ms. Palmer is able to reflect on the areas of growth for this lesson and can better support students in the future.

Areas for Growth

Student responses to comprehension questions lacking evidence

- Example: Each student wrote that their data was proportional to the actual data but did not provide calculated evidence to support this claim.

Further finding the WHY behind the WHAT. WHY are we making scale models?

- Example: Answer to scale model importance question should have mentioned fields of study that could use models in pre production stages of building. Also, the importance of modeling in space exploration and discovery
- Teacher should further define the why at the start of the lesson to promote greater connection and understanding of the activity.

Errors in Data Calculation

- After the selection of Earth's diameter, the teacher should record each group's diameter. Then, the teacher should create answer keys for each scale diameter chosen. This would allow for quicker feedback, and clarification on miscalculations.

Reflection

- [ ] Link to Lesson Implementation Reflection
- [ ] Link includes work cited

Thanks for Listening!