LESSON PLAN

Teacher: Date: Prior to "Give Me Space!" performance

Grade Level/Subject: 4th/Math & Science Co-Teaching Model Utilized:

Central Focus:

To only serve as a predecessor classroom activity accompaniment for students meant to experience the performance of "GIVE ME SPACE!" During the performance, all students will intentionally hear musical compositions written for each of the 5 – IAU established dwarf planets and acknowledge as fourth graders their previously conducted study where constructing 3-D volumetric scaled models indicate their relative sizes to one another, positioning locations in- and outside of our solar system, while also learning of their reasons of qualification as dwarf status and then additional physical properties.

Standards:

Math
4.NF.B.3. Understand a fraction a/b with $a>1$ as a sum of fractions $1/b$.
4.NF.B.4. Apply and extend previous understandings of multiplication as repeated addition to multiply a whole number by a fraction.
4.NF.B.5. Express a fraction with denominator 10 as an equivalent fraction with denominator 100, and use this technique to add two fractions with respective denominators 10 and 100.
4.MD.A.1. Measure and estimate to determine relative sizes of measurement units within a single system of measurement involving length, liquid volume, and mass/weight of objected using customary and metric units.
4.MD.B.4 Make a line plot to display a data set of measurements in fractions of a unit. Use operations on fractions for this grade to solve problems involving information presented in line plots.

Science
4.ETS2:1) Use appropriate tools and measurements to build a model.

Objective(s):

Volumetrically scaled clay-type models of 5 dwarf planets: Ceres, Pluto, Haumea, Makemake, and Eris are made from one whole amount of Play-Doh representing all 5 volumes massed together and then subdivided proportionally into their equivalent parts. Reasons for the 'dwarf' nomenclature are characterized. Positions of each are investigated including other physical properties of interest.

Academic Language Demands:

Dwarf planet	Hydrostatic equilibrium
International Astronomical Union (IAU)	Clear the neighborhood
Natural satellite (moon)	Sun
Asteroid	Diameter
Ceres	Fraction
Pluto	Proportion
Haumea	Volume
Makemake	Sphere
Eris	Comets

Accommodations:

All students may need consistency in correctly kneading the Play-Doh to ensure proportionality distribution and a block of wood may help.

Assessment Measures:

Formative: Q & A during lesson and success of activity accomplishment determined visually
Summative: None

Materials:

Play-Doh
Ruler
Block of wood used to aid in consistent kneading of clay into cylindrical form

PROCEDURES & TIMELINE

Introductory Set:

Discuss Pluto's planetary demise.
Suppose all the asteroids in the asteroid belt were melded together. Introduced fact: they would not come close to even volumetrically equaling our Moon. In a reverse consideration, a single mass of clay is to be subdivided into proportionally equal parts to represent the 5 IAU identified dwarf planets. Given known proportions, 4 of the 5 will be modeled as nearly spheres while one will not.

Work Session:

One mass of clay is rolled into a tube/cylinder ideally 50 cm long with a constant diameter from one end to the other needed so as to use base 10 divisions more easily. Considering known values of each dwarf planet volumes, they are added together and a proportion is figured for each in terms of percentages.

Summing the calculated volumes in terms of cubic kilograms:

Ceres	0.42×10^9
Pluto	7.1×10^9
Haumea	2.4×10^9
Makemake	1.7×10^9
Eris	6.6×10^9
Sum	18.22×10^9

Computing the percentage of one, (Pluto), shows a pattern to be followed in determining the sizes of each.

100 x (7.1/18.22) ~ 39%

If the tube/cylinder shape made earlier is 50 units long, Pluto's part would be 19.5 units. 19.5 units is cut away and rolled into a spherical shape. Likewise, for all others except Haumea. Haumea is elliptical in shape with a major axis of 4, minor axis of 3.

If a pocket solar system is used from the 3rd grade lesson plan, approximations can be shown as to where the other dwarf planets exist in relationship to the Sun (mean orbital radii based) keeping in mind that all of the dwarf planets carry more elliptical orbits than the eight planets and even at greater inclinations to the ecliptic plane as indicated in the following table with additional approximations also given about other physical properties.

Trait	Ceres	Pluto	Haumea	Makemake	Eris
Mean Orbital Radius (cm from Sun end on model)	7	100	110	116	170
Inclination to ecliptic (degrees)	10.59	17.14	28.22	28.96	44.19
Mass (x $10^{21} kg$)	0.94	13.05	4.01	?	16.7
Density (g/cm^2)	2.17	1.87	1.8	>1.4	2.5
Surface Gravity (m/sec^2)	0.29	0.58	0.44	?	0.8
Surface Temperature (°F)	-159	-381	-402	-406	-384
Day (Earth hours)	9	-153	4	8	24
Moons	0	5	2	1	1
Orbital period (years)	4.6	248	283	310	557

Closure:

Make conclusions as to steepness of ecliptic inclination for each, order from least to greatest for mass, density, surface temperature, surface gravity, orbital period. Do these have a logical sequence?

How might the musical scores for the dwarf planets be written by you and have the possibility of sounding like their physical characteristics; like mood, tempo, temperatures, isolation as compared to Gustav Holst's The Planets.

Lesson References:

https://en.wikipedia.org/wiki/Dwarf_planet
https://en.wikipedia.org/wiki/Ceres
https://en.wikipedia.org/wiki/Eris
https://en.wikipedia.org/wiki/Haumea
https://en.wikipedia.org/wiki/Makemake
https://en.wikipedia.org/wiki/Pluto