Your Galactic Address: Space, Place, and Perspective

Amanda Amanullah, M.S.Ed.
Henry C. Lea Elementary School

Overview

Space and place are abstract concepts until they are defined with quantities and scale. A child's spatial reasoning develops as they explore objects through touch and sight. That logic and reasoning expands and becomes more tangible as they learn about location and relativity in larger spaces (such as neighborhoods or towns), often through physical observation and exposure to maps or diagrams. Achieving a thoughtful and accurate realization about your location and size, relative to the globe, however, is a much bigger concept. Even more challenging is the idea of your place within the solar system, galaxy, and universe. The conceptualization of "**our place in the universe**" not only deepens the understanding of Earth and environmental sciences but it also provides better access to history, math, social sciences, and hard sciences through language, problem solving, and reasoning skills.

Rationale

While considering this idea for a curriculum unit, I started my research at *the source*. I asked one of my fourth graders "*Where are you right now?*" He looked around, briefly, and then replied, "*I'm in school*." When I probed the idea further and asked, "*How else can you explain where you are right now?*" He quickly said, "*In the back of the room?*" I found it interesting that my student decided to zoom in on the location within the context of the building, and then our classroom, rather than note the larger area, such as the neighborhood of West Philadelphia or the state of Pennsylvania.

My students are from the West Philadelphia area. They are familiar with the landmarks and general geography of their neighborhood. However, they rarely tell me that they've ever left Philadelphia. There are a handful of students who mentioned that they've been to New Jersey or New York, but only a small percentage of my class. When I asked them about other neighboring states, in terms of geography, location, or environment, they have very little to no knowledge. Regardless of the economic requirements of travel, knowledge of our surroundings is integral for purposes of comparing, contrasting, and understanding the environment with more depth and context. Geography is a subject that deserves more focus in schools, especially at the elementary level when students begin to construct ideas and understandings of the world around them.

A unit such as this one would provide tremendous opportunity to study space and place as an inquiry-based scientific subject. If my kids do not have the luxury of traveling beyond Pennsylvania, we can certainly discover other territories as a class using Google Maps, tactile activities, images, videos, and more. While all of that would be an introduction, the extension of study to the "observable universe" is the focus and would answer essential questions formed during precursory lessons. A deeper comprehension of the size and positioning of us and our planet would also pave the way to a better understanding of individual positioning: *What is your place in the universe? How will you leave your mark? What does the vastness of space tell us about life? How can you apply this information to Social Studies or Math or Reading?*

In working with my fourth graders students this year, I noticed that there was a general weakness in quantitative logic and reasoning skills and a lack of interest in math. I learned this through surveys, narrative observations during Math class, number talks, and student's open-ended responses to math problems. Constructed responses are a requirement for students taking the PSSA. Students must explain their reasoning for solving a problem in a certain way, revealing knowledge of strategies and number sense. To practice this technique, I used "number talks," which were meant to make students more comfortable with describing their thought process and being open to the idea that there can be multiple ways to solve one problem. However, number talks were not enough. My kids needed concrete examples and real-life applications.

While teaching fractions, it was difficult for my kids to comprehend that two fractions with different numbers (such as 1/3 and 2/6) are equivalent to each other. The fact that numbers "represent" quantities is more complex than it sounds, especially when you have to manipulate those numbers to solve problems and describe natural phenomenon. Using fraction blocks and Smart Board programs helped us reach our objectives. The concepts really clicked for them when we used relatable problems and tangible ideas. Referring to fractions of pizzas and pies in story problems led to a better understanding. Using real objects and models furthermore led to mastery for some of my students. Mastering the foundational concepts behind comparing two numbers, two sizes, or two distances would result in more meaningful applications of math in astronomy.

In surveying most of my students, they've said they "do not understand math" or are "just not good at math" which is a stark contrast from their self-reflections about reading and writing. This unit would tie together the necessary pieces and skills that are not only integral for academic success but also transferrable to careers and future education. Students must have a mastery of place value, which can take up to a full marking period to teach and reteach, and number operations. Fractions and ratios don't enter the picture until much later and can sometimes be overwhelming for those students who are struggling with basic concepts. Tying mathematics to a high interest subject like astronomy (space, planets, stars, etc.) would create a whole new application of concepts that could illuminate understandings about patterns, formations, distances, and geometry in an interdisciplinary and seamless way.

Geometry is another area that is easily brushed over in fourth grade. With a focus on multiplication and division in the second marking period, in preparation for fractions for the third marking period, geometry is often taught in between these skills. For my kids, geometry was one of the most engaging math units due to the visual aspect and the vast possibilities of applications, such as art, architecture, and sports. As our final geometry project, we built pop-up paper cities using angles and geometric shapes. An assessment like this would simply be made richer if placed within a unit about space and place. The interdisciplinary connections are extensive and we need to take advantage of the versatility of this subject.

As with any subject from history to literature, I want my students to dig deep, close-read, and look within an entity. The missing piece is often the expansion of the skill and the connection to a larger concept or idea, text-to-world connections. I want my students to start thinking about how every little thing connects to a larger picture. One inventor plays a role in a vast history of technological advances. One word plays a role in a thousand-page book. One state plays a role in the country. One person's position plays a role within the human race and across the globe, which plays a role in the solar system, which plays a role in the universe, and so on. In order to create that cognitive image of scale in astronomy and make it applicable to real world situations, **zooming out** is as important as **zooming in**.

Today, science education is defined as "doing science", as opposed to memorization of facts or teaching out of a textbook (Seefeldt & Galper, 2002). The Next Generation Science Standards (NGSS) were created to address this exact concern and promote STEM education. As the School District of Philadelphia adopts these science standards into K-12 education, my school has taken one step ahead by beginning the planning and implementation process during the 2015-2016 school year. I've analyzed several NGSS standards and skills and learned how to best integrate them into existing curricula. I strongly believe that this framework sets a solid, sensible, and meaningful foundation for better and more targeted STEM education.

NGSS divides science learning into three distinct and important dimensions: crosscutting concepts, science and engineering practices, and disciplinary core ideas. **Crosscutting concepts** have to do with "cause and effect" and help students develop a scientifically based view of the world. **Science and Engineering Practices** describe what scientists do when observing the natural world and include "inquiry" in the range of cognitive, social, and physical practices. The **disciplinary core ideas** are the key concepts that have importance across multiple disciplines - they are meant to build on each other as students' progress through grade levels - similar to Common Core standards for literacy or math skills. The point of creating this 3-dimensional model is to help students deepen and build core ideas attached to scientific knowledge as opposed to random skills or activities that has become the typical experience for elementary- level science.

This unit about "Your Galactic Address" highlights NGSS as an agent, to help engage students in the scientific process through multiple modalities and literatures. The learning progressions provide real-world applications, a better teaching of STEM skills, and the opportunity for authentic learning assessments with practical targets. In fourth grade, NGSS begins its foray into "Earth's Place in the Universe." Since the fourth grade focus is on Earth and landscape and the 5th grade focus is on light, time, and seasons, it would be beneficial to then incorporate the concept of *your galactic address* in between these two ideas. According to the fourth grade standards, students learn about how the layers of rock tell a story - both a historical and scientific narrative - about the earth. In the same way, students will be able to understand that the location of objects in space, including our own, tell a story about where we were, where we are, and where we are going.

Knowing that many of my kids are naturally interested in scientific topics but often lack the specific facts and connections, it is important to touch upon prior knowledge and use that to build an appropriate background for the rest of the lessons. Students would need to know their own postal addresses and practice **map skills**. This includes learning how to read and apply a map legend, how to interpret a map, how to differentiate between cardinal directions, how to position oneself or the map as necessary, and how to interpret the actual distances between the objects on the map. This ties in with our geography and social studies units, moving into Land and Water. I also typically conduct a two-week unit about inventions and engineering concepts, which include biographical study of Benjamin Banneker and social-historical study of the "**almanac**". This is a perfect example of a Social Studies segue into a unit about astronomy and the universe, because the connections between history, observation, and perspective are clear.

Students would also need to be able to put various **measurements of distance** and size in increasing order and be able to compare them, such as kilometers vs. meters or inches vs. miles. This would be covered in our math block but must be reviewed in terms of the larger numbers that would be covered in the unit. Teaching students how to represent larger objects with smaller symbols or longer distances with smaller scales would be fitting and provide students with the practical skills to help them make sense of the physical science concepts in the unit.

From my experience with teaching fourth graders I also believe its important to address issues of identity and **self-awareness** through the smooth integration of social-emotional concepts into everyday curricula. In this case, upper elementary students are at a pivotal point in their lives, psychologically and developmentally. As pre-adolescents many of my students are experiencing a life transition and the resulting emotions or actions are often expressed in how they see their environment - family, social circles, education, and other components. In terms of school, there are added responsibilities - standardized testing, higher expectations, and a lot of preparation for middle school. Therefore, it is a significant time for students to reflect on their **positions within the larger scheme** of things. I want my fourth graders to start considering their perspectives in life and the idea that perspectives can differ per person or entity. Finally, I want them to come to the understanding that **perspectives** and point of view are valid for **personal reflection** as well as social change. I believe all of this could easily start with a basic comprehension of positioning - starting with physical (in science lessons) and transitioning to mental (in literacy lessons), and vice versa.

Background

Spatial thinking involves comprehending and analyzing the phenomena related to the places and spaces around us - including the scales, locally and globally; the larger the scope, the greater the concept, and the deeper and more creative the perspective. Thinking about space through a scientific and physical lens would allow students to become critical thinkers and connect past, present, and future through a basic yet necessary understanding of the human race and its position in the larger scheme of things. Thinking of space as a series of structures we can zoom out and zoom in on, rather than two-dimensional images and maps is possible. After analyzing the locality of a neighborhood, city, state, country, and hemisphere, zoom out to our planet. Here are some suggested points of focus to create a trajectory of layers:

Planet Earth: Earth is defined as the planet on which we live, the world, but it is a mere piece of the universe. What role does it play in the solar system? What role does it play in the universe? How is the world affected by other things that happen in the universe, such as the positioning of the Sun? How do we, on Earth, perceive the happenings of the universe, such as the collision of black holes or the movement of our satellites?

The Earth-Moon System: The Earth and the moon are easy to see from outer space. Though the moon is also massive, it would be about one fourth of the Earth’s diameter. The ratio of their masses is larger than the ratios of other satellites to the planets they orbit. Because of this, the Earth and the moon are sometimes referred to as a "double planet."

The Solar System: Our solar system consists of the Sun, our star, and the planets, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. Pluto is considered a dwarf planet but can be mentioned for comparison as well as current events regarding the definition of planets and space exploration. Our solar system also includes satellites of planets, comets, asteroids, and meteoroids. The Sun provides the most electromagnetic energy in the form of heat and light. The nearest similar star is Proxima Centauri, a red dwarf star, that is 4.3 light years away.

The Milky Way is our galaxy, a spiral disk of 200 billion stars that include our solar system. Nearby, are two smaller galaxies, the Large Magellanic Cloud and the Small Magellanic Cloud, which are visible from the Southern Hemisphere on Earth. A larger galaxy is the Andromeda Galaxy, also in a spiral shape but four times as big as the Milky Way and two million light years away.

The scale of the Solar System can be described as the Sun as a soccer ball in the middle of a planetarium theatre. The Earth would be a plant seed and just outside the planetarium. The distance unit used to describe distances within our solar system is an Astronomical Unit (au). 1 AU is the average distance between the Earth and the Sun and is equivalent to 93 miles.

An info graph created from a Stargazing Live episode on BBC (2012) provides a fun example of scale in the solar system. If the largest planet, Jupiter, is a watermelon, then Mercury is a peppercorn, Venus and Earth are cherry tomatoes, Mars is a blueberry, Saturn is a large grapefruit, Uranus is an apple, and Neptune is a lime. These are not exact ratios, but can be visually appealing and engaging for elementary students.

The composition of the solar system can also be described as follows: The Sun is 99.85%, the planets are 0.135%, comets are 0.01%, and satellites are 0.00005%. Percentages are not a mathematical focus in fourth grade curriculum but will be in fifth grade. That is why using diagrams in the form of pie charts, bar graphs, of info graphics would help students visualize these percentages and ratios.

The Milky Way Galaxy includes the Sun, the planets, and about 400 billion stars. It is so vast that some distances between stars are expressed in light years. One light year is the distance that light travels in one year.

The Local Group is a cluster of more than 54 galaxies, including our own. Most of them are dwarf galaxies and the gravitational center is somewhere between the Mily Way and Andromeda Galaxy. The local group covers about 10^{23} meters.

The Virgo Supercluster is a concentration of galaxies that contains the Local Group and thousands of other galaxies.

The Observable Universe can be shared with students via the famous Hubble Deep Field (HDF) image taken by the Hubble Telescope and a storytelling technique. In 1995, the Hubble spent 10 days honing in on one, tiny patch of the sky. The result was an image of nearly 3,000 galaxies that looked back to the beginning of the universe. It revealed to us that there are more than one hundred billion galaxies in the universe. The Hubble website offers several other breathtaking photos that can be used in this unit to "show" rather than "explain" the vast scale of the universe and the various technological advances that have allowed us to observe and explore it despite the sizeable distances.

The observable universe technically contains a large number of clusters of galaxies that are spread across with some apparently empty regions called voids. Our current view of the observable universe is more than ten billion light years in each direction.

Objectives

This unit is designed fourth grade students meeting five times per week, 45 minutes at a time, for 2-3 weeks. The unit is designed for fourth grade but can be adjusted for a span of fourth-6th grade to introduce the NGSS theme "Earth's Place in the Universe."

It would apply to the 5th grade curriculum about earth and space science and act as transitional units for fourth and 6th grades, filling in the gaps of the existing standards. A more advanced group of students may expand the mathematical thinking to powers of 10, decimals, combined number operations, and algebraic thinking. A lower-level group of students may need more differentiation when it comes to converting units and numbers. It is important to note that 6th graders will have a better understanding of space science (our solar system, planets, and satellites) while fourth graders will have a basic understanding of localized, earth science, based on NGSS standards.

The Objectives of the unit include:

- Identify your address within the political globe
- Identify the Earth's place in the solar system
- Compare the size of Earth to other entities in the solar system
- Describe the size of your neighborhood, town, state, country, hemisphere, Earth, solar system, and galaxy with quantities and comparisons
- Determine the distance between the Earth and the Sun, the Moon, and neighboring planets and the implications on human life

- Describe Earth's spatial positioning (tilting, revolutions) and the implications on human life
- Utilize words to describe scale of people and planets (extent, proportion, range, rate, ratio, scope, system)
- Describe your perspective of the solar system

Standards

The Philadelphia School District uses the PA Common Core set of standards for Reading, Writing, and Math. We are also making the transition to Next Generation Science Standards (NGSS) and these standards can be embedded into the Common Core framework:

(1) Reading

- Refer to details and examples in text to support what the text says explicitly and make inferences.
- Explain events, procedures, ideas, or concepts in a text, including what happened and why, based on specific information in the text.
- Compare and contrast an event or topic told from two different points of view.
- Integrate information from two texts on the same topic to demonstrate understanding of that topic.
- Acquire and use accurately grade- appropriate conversational, general academic, and domain-specific words and phrases that are basic to a particular topic.

(2) Writing

- Write informative/ explanatory texts to examine a topic and convey ideas and information clearly.
- Use precise language and domain-specific vocabulary to inform about or explain the topic.
- Provide reasons that are supported by facts and details.

(3) Speaking & Listening

- Engage effectively in a range of collaborative discussions on grade- level topics and texts, building on others' ideas and expressing their own clearly.
- Draw evidence from literary or informational texts to support analysis, reflection, and research, applying grade-level reading standards for literature and informational texts.

(4) Math

- Generate and analyze patterns using one rule.
- Draw lines and angles and identify these in two-dimensional figures.

- Recognize symmetric shapes and draw lines of symmetry.
- Solve problems involving measurement and conversions from a larger unit to a smaller unit
- Translate information from one type of data display to another.

Strategies

There would be a focus on inquiry-based methods and the 5 Es of science education: ***engaging, exploring, explaining, elaborating,* and *evaluating***. Using this as a basis for an instructional rubric would provide both the teacher and the students with a framework for expectation. In addition, NGSS Practices and Crosscutting Concepts that align most with this curriculum are:

- constructing explanations
- recalling information
- drawing evidence
- reasoning abstractly and quantitatively
- creating models to express phenomena

Applying these strategies to assessments involve posing questions and being able to find solutions, expressing solutions in a variety of mediums (including but not limited to creating models, diagrams, maps, and narratives), and defining concepts with values. As they grasp the concepts about the solar system and Earth's location in the universe, they should be able to make predictions using evidence while identifying significant facts and patterns that support their claims. To avoid the concepts in this unit being overwhelming or too fast-paced, **scaffolding** is necessary. Teachers should help build up knowledge through a progression of understandings and basic objectives so that students can prepare themselves for each day and each lesson. Multiple forms of **assessments** would allow one to gauge their understandings - a combination of exit tickets, 2-dimensional models, 3-dimensioal models, class discussions, and journal reflections, across disciplines.

There are some specific points to consider before teaching this unit:

(1) Tactile Activities

Students are engaged and when experimenting with materials or conducting tactile activities. Incorporating process skills, such as observing, predicting, and measuring, helps cultivate their knowledge. It is not just the activity, but also the process of reflection that can lead to new ideas and conceptual understanding. Taking this into account, this unit should include several opportunities to build physical models and use real objects to understand space and scale. Reflection pieces and open-ended components are encouraged to tie in with writing and research standards.

This unit also provides the opportunity to expand technology use to Science and Math. A Smart Board or Promethean Board would provide the opportunity for students to interact, physically zooming in and zooming out, and getting the chance to move objects around to model distances and display them on the board. Google Maps and Google Earth are highly encouraged as complimentary activities. Scavenger hunts can be created while a global positioning system can be used as a tool, an interactive map. Other interactive programs are available on Scholastic.com, Smart Exchange, Teach Hub, and collaborative websites.

(2) Student-led Discussions

Elementary students are highly expressive. It is as if every chance they get, they want to share ideas, stories, opinions, and narratives. My goal is to channel this energy and willingness into productive thought and meaningful connections. I want them to be able to open up to the idea that we all have different experiences, stories, and perspectives in life, just as the view from a spaceship and the view from your bedroom window provide different visuals and expressions of the same object.

As mentioned in Koch (1996), students' spontaneous curiosity provides opportunities to change the original plan and mediate the experience. The kinds of discussions that seem more student-led or feed off of the current understanding and inquiries of the group are more successful. We would always begin with the students conceptual thought and allow students to build understandings off of each other's comments. This requires a high level of classroom management and a couple of lessons about how to have a discussion. The sharing of perspectives is also integral because it is emblematic of the concept of relativity - students should be open to other interpretations and viewpoints than their own.

(3) Scientific Process

An aspect of incorporating prior knowledge is understanding that a child's misconceptions are his or her attempts to make sense of the world around them (Michaels & Shouse 2007). Making sure to build from their current understanding of space and place will be crucial to consider from Day 1. This is also reflective of the scientific process itself as it allows students to pose hypotheses and follow through checks and steps to determine and explain the ideas they came up with themselves. At the beginning, it will be imperative to explain to students they are like "scientists" and "researchers" during these lessons and beyond. The intention is to make students feel accountable for themselves as learners, and consequently, engage them in their own learning (Victor 2008).

Activities

Starting with the “self” students would discuss their interpretations of where they are located, and a general, basic understanding about relativity through the study of perspective. Students will consider the implications of point of view: first-person, second-person, third-person by practicing with physical stance and camera lenses. The teacher may present an example of a role-playing video game and discuss what the point of view might be. Once students have mastered the difference between omniscient and limited, it will be interesting to engage them in the idea of multiple points of view in real life as opposed to the one we may choose when we write a story or do research. Possible guiding questions are: *How would your point of view change if you were looking down (helicopter view) of the city as opposed to looking forward (if you were walking through it). What is different or similar about these views? Which one is appealing to you and why?* The teacher may provide a series of images with the same subject but a different focus and ask: *What is similar between these pictures? What is different about them? What do you get out of one and not the other?*

Getting the discussion started about perspective and point of view would help expand curiosity and engagement while creating dialogue about physical positioning and location. Teaching maps would come next. A variety of maps, including environmental, historical, national, etc., as well as sizes should be included to provide a more versatile knowledge. For example, teachers may include a map of the city, the United States, and the world. This activity can be inquiry-based, dividing students into groups and simply asking what they notice about the maps. Guiding Questions: *What information does each map provide? How do these maps relate to each other? What if you had to draw a diagram connecting these maps - how would you do it? If you had to place yourself in this map, where would you be?*

After creating this background knowledge, students will be able look at maps and create their own drawings to depict their understanding of location and space. Students will then build upon that by zooming out, one step at a time. They would connect concepts through the use of diagrams and charts - anchor charts with the entire class as well as collaborative projects. This should be done alongside direct instruction about the solar system at each of the layers mentioned above in the Background section. At each layer, students should be able to replicate the model using two-dimensional and three-dimensional simple objects, such as a drawing to depict the Milky Way Galaxy or a model of the solar system using Play-Doh, as described in an activity below.

This is also where math comes into play. Ratios and scale should be introduced at the start of the unit and built upon at each of these layers. By the end of the unit, students should be able to connect each of these diagrams and depictions into one, large physical display and present mathematical representations in the form of quantitates, ratios, or comparisons.

Lessons and activities should be differentiated as appropriate. Breaking up groups or pairs by skill mastery and reading level is recommended. Whole-group instruction for science concepts would allow everyone to receive the same information, but videos, images, and models are encouraged to pique student strengths from visual to kinesthetic intelligence. Inquiry-based activities should have a mix of levels and abilities in each group to create the most versatile experience for students.

Understanding Proportion and Ratio

As mentioned above, fractions are integral in fourth grade. Alongside fractions, students should also have knowledge of ratios and comparing one value with another. Number comparisons using quantities and qualifiers are necessary and can be taught using fraction blocks, fractions sticks, and place value cubes. Study maps to learn what proportion of the world is land and what percentage is water. Use inquiry-based activities to help students learn the difference and crossover between proportion/ratio, percentage, and fraction and how to use each of these concepts to describe the same concrete description or quantity. Provide opportunities for students to practice coming up with both exact and approximate ratios and begin using everyday objects to represent this.

Understanding the Size of Planets

In these activities students would use materials to create accurately sized planets. NASA provides a solid activity based on this objective that has been adjusted for the purposes of this unit, below. Suggested materials include Play-Doh or clay, a set of instructions pre-written for each student, and a planetary placemat. Appendix A includes the set of instructions and Appendix B is the planetary placemat. A tip is to provide students with a straight edge in order to be able to cut the Play-Doh into pieces. Students would follow each instruction with a partner and create an experience of exploring the sizes of planets, rather than just learning the numbers. This activity should take place after students have a basic understanding of the order of planets, what each planet is made of, and the general sizes of the planets in relation to Earth.

At various points in the unit, images of Earth and nearby planets and the solar system should be used as do-nows and exit tickets. Students would be asked to discuss and evaluate for accuracy. Many depictions of the solar system are not to scale but getting students to realize this on their own would make this unit much more meaningful. By the last day of the unit, students should be able to discern the changes needed to make an illustration of the solar system as accurate and to scale as possible. Real satellite images should also be used to spark discussion and questions.

Create a concept board about “Size and Scale” in the universe and add these questions as the unit continues. Students should be given post-its at the beginning of every science lesson. As many students might not want to share their questions openly in discussion, a concept board provides another medium for expression. Answers may be added to the same board from other students conducting individual research or the teacher posting articles and facts that pertain to student questions.

Understanding the Distance Between Planets

After reviewing the planet order and relative sizes, students should be asked to identify the planets and their locations. Students should, by now, be able to describe the sizes using phrases such as “bigger than” and “smaller than.” *What do you notice about the sizes of planets? How do you think the sizes compare? Would it be easy or difficult to model them? What objects can we use to accurate represent the difference in sizes and distances?*

At this point, teach students about astronomical units in that they are simplified numbers used to describe a planet’s distance from the sun. *Why do you think we use astronomical units?* The distances in our solar system are so large that it would be easier to comprehend and manipulate them if they were smaller. We can also then use them in calculations and comparisons. *What is the best unit to use to describe the distance between planets and why?*

Many activities, such as National Geographic Society’s “Planet Size and Distance Comparison” align with this part of the unit, though they must be adjusted for fourth grade. Students can divide into groups of 10 so that one student can represent the Sun and the others can be the planets. This must be done in a large area such as the playground, gym, parking lot, or if nothing else, then the hallway. The students would start in the same spot and the child representing the Sun would remain there. The student representing Mercury would move 1 step away from the Sun. The student representing Venus would take 2 steps away from the Sun. Earth would take 2.5 steps away and Mars would take 4 steps away from the Sun. If there’s an extra student he or she could be the Asteroid belt and take about 4 steps away from the Sun. Jupiter takes 13 steps and Saturn takes 24 steps away from the Sun. Uranus and Neptune need a lot of room as Uranus would take 49 steps away from the Sun and Neptune would take 76 steps away from the Sun. 100 steps away is the Kuiper belt. Ask students*: What did you notice during this activity? Were you surprised by anything?* Students can leave objects in their places and then walk around to observe these distances, furthermore being able to understand the purpose and applicability of “scale” for sizes and distances in astronomy.

Understanding Your Position Within the Universe

The final assessment is a small-scale model displaying an understanding of distances, sizes, and locations, along with a written narrative, to accurately portray the student’s location within the vicinity and the galaxy level. It is a summative, portfolio assessment in which students would put together each layer they have created (i.e. self, classroom, school, block, street, neighborhood, city, state, country, continent, hemisphere, planet, solar system, and galaxy) throughout the unit in a simple but sensible model to illustrate their understanding of size and distance in the solar system. Students would use mathematics (ratio and proportion) within the model and also provide a written narrative about their personal location in the universe. The guiding questions to be asked are: *What is your galactic address? How would you describe your place in the universe?* These can also be the "essential questions" for the overall unit presented on the first day.

Suggestions for unit vocabulary include but are not limited to:

Tier 1 words/phrases:

- More than
- Less than
- Twice as much
- Three times as much (etc…)
- Half of
- One third of (etc…)
- Size
- Scale
- Distance
- Exact
- Estimated
- Globe
- Universe
- Space
- Location
- Comparison

Tier 2 words:

- Approximate
- Ratio
- Model
- Fraction
- Percentage
- Proportion
- Circumference
- Orbit
- Radius

- Relative Size
- Relative Distance
- Position
- Navigation
- Perspective
- Point of View
- Conversion
- Representation

Tier 3 words:

- Diameter
- Astronomical Unit
- Galaxy
- Planet
- Satellite
- Rotation
- Axis
- Revolution
- Dwarf Planet
- Kinesthetic
- Mercury
- Venus
- Earth
- Mars
- Jupiter
- Saturn
- Uranus
- Neptune
- Global Positioning System

Activities performed throughout the unit can be differentiated by adjusting the number of tasks, scaffolding the tasks, and student groupings and pairs. They should provide opportunities for students to explore and inquire about objects, gaining a more applicable and analytical view of shapes, sizes, and distances. Major activities would be direct applications to the knowledge of space, whereas the daily, mini activities would both teach new concepts and reinforce them.

Annotated Bibliography

Research and Educational Frameworks:

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> *This was a study comparing the effectiveness of conceptual change oriented instruction through cooperative learning and traditional science instruction on fourth grade students' understanding of earth and sky concepts and their attitudes towards earth and sky concepts.*

Bransford, J., Brown, A. L., Cocking, R. R., & National Research Council (U.S.). (1999). How people learn: Brain, mind, experience, and school. Washington, D.C: National Academy Press.

> *This book offers research about the mind and brain and answers questions about what teachers can do with curricula, classroom settings, and teaching methods to help children learn most effectively. It examines findings and their implications for what we teach, how we teach it, and how we assess what children learn.*

Koch, J. (1996). Planning for Science: Lesson Plans and Instructional Strategies. In Science Stories: Teachers and Children as Science. Mifflin Company Learners. Boston: Houghton Mifflin Harcourt.

> *This chapter describes the difference between a science activity and a science lesson and the effectiveness of learning independently or in small groups. It provides strategies for planning for the unexpected in science lessons nad how to set them up appropriately for 40-45 minute periods.*

Jiyoon Yoon. (2006) Teaching Young Children Science: Three Key Points. Early Childhood Education Journal.

> *This report covers the idea of "doing science" as opposed to the memorization of facts and provides developmentally appropriate practices in the context of teaching science. The use of questioning and the 5 Es instructional model are also discussed.*

Michaels, S., Shouse, A. W., and Schweingruber, H. A. (2007). Ready, set, science!: Putting research to work in K-8 Science classrooms. Washington, D.C.: National Academies Press.

This book provides groundbreaking research about teaching and learning science from Kindergarten through Eighth Grade. It has classroom case studies that bring research to life through real stories and experiences from Science teachers. It has information on how teachers select and design instructional tasks and orchestrate productive discussions with a diverse group of students.

Victor, E., Kellough, R. D., & Tai, R. H. (2008). Science K-8: An Integrated Approach, 11th Edition. Pearson.

This book is based on integrated learning by inquiry and is the cornerstone used for science teaching. It covers the developmental components of "why, what, how, and how well" of teaching with complete content outlines for concepts of life, earth, and physical science. It is very useful for building sequences and units.

Teacher Readings and Literature:

Mika, Anna. (2015). Planetary Size and Distance Comparison. National Geographic Society. http://nationalgeographic.org/activity/planetary-size-and-distance-comparison/

This is an extremely useful activity page with ideas, suggestions, and overviews for teaching the diameter and relative distance of each planet from the Sun. It covers astronomical units and tactile activities. Since it is written for Grades 6-8, it would need to be adjusted for elementary school, as I have done with one of the activities above.

Cox, Brian and O'Briain, Dara. (2012). Stargazing Live: Lesson Plans. BBC TWO. http://downloads.bbc.co.uk/tv/guides/BBC_Stargazing_Live_2012_Lesson_plans_KS2.pdf

This PDF provides a wealth of lesson plans and ideas for teaching about the Earth, Sun, and Moon, including phases of the moon, seasons, and telescopes. It was created by professors in order to fascinate children about space. This packet has worksheets, links, objectives, plans, assessment ideas, and extension activities.

Hubble Site. (2015). http://hubblesite.org/

This website is chock full of information and interactive opportunities for both teachers and students. It includes news, images, videos, blogs, and discoveries. It is details and well planned, easy to navigate. It also includes a section about the Webb Telescope.

Student Readings and Literature:

Evert, Laura and Garrow, Linda. (2003). Planets, Moons, and Stars: Take-Along Guide. ISBN: 978-1559718424. Cooper Square Publishing.

This is a 48-page text that introduces the world planets, moons, and stars with identification information, facts, an educational activities.

Hughes, Catherine. (2012). National Geographic Kids First Big Book of Space. ISBN: 978-1426310140. National Geographic Children's Books.

This book has colorful illustrations and simple text that can be used for read aloud or independent reading. Though the reading level is lower than fourth grade, the book is high interest.

Cole, Joanna. (1992). The Magic School Bus: Lost in the Solar System. ISBN: 978-0590414296. New York: Scholastic, Inc.

This is a staple book for this unit and can be read aloud to the class. The fictional Mrs. Frizzle and her students embark on a journey into space, exploring each planet. It includes humor, relatable characters, and a great storyline for kids to follow along with.

Warner Home Video. (2009). Magic School Bus: Space Adventures. Scholastic, Inc.

This cartoon science adventure is similar to the book, above, but is even more engaging. It has accessible facts about flight, asteroids, and the solar system.

NASA Space Place. http://spaceplace.nasa.gov/menu/solar-system/

This website is geared towards kids and provides interactive and colorful explorations into various topics, including Earth, Sun, Solar System, Universe, and Science and Tech. It includes games, crafts, and media that appeal to kids and answer questions about space.

Ology. (2015). American Museum of Natural History. http://www.amnh.org/explore/ology/astronomy

This is a kid-friendly website all about astronomy. It explores how the universe began as well as "our place in space," specifically. It is very interactive and includes appealing activities, such as scavenger hunt, moon flip book, astronomy stationary, cosmic wallpapers, etc. that can be used as Science Center activities or fun extensions for early finishers and extra credit.

Readworks: Stargazing. http://www.readworks.org/passages/stargazing

This is an informational text leveled at 920L. It includes two pages of texts and comprehension questions, vocabulary, and paired texts. It describes general details about stars in our galaxy and facts related to distance.

Readworks: What's Up In Space: http://www.readworks.org/passages/whats-space

This is an informational text leveled at 670L. It includes one page of text and comprehension questions, vocabulary, and paired texts. It provides a general overview of our solar system.

Guidone, Lisa. (2012). Readworks: Living on the Moon. (2012). http://www.lee.k12.nc.us/cms/lib03/NC01001912/Centricity/Domain/1464/living%20on%20the%20moon.pdf

This is a kid-friendly informational text describing NASA's journey and U.S. Space Travel, from the moon to Mars.

Ology, The American Museum of Natural History. The Milky Way Galaxy (2013).

This is an informational text describing The Milky Way Galaxy in appropriate language for elementary children.

McGibney, Megan. Readworks: The Every-Changing Sky. (2015).

This is a creative informational text written in the second-person to describe local components and happenings of the universe. It includes multiple choice and open-ended questions.

Appendices

Appendix A

(Inspired by NASA website)

SWBAT interpret instructions and create models IOT demonstrate relative planetary sizes and distances.

1. Divide the entire ball of Play-doh into 10 equal parts
You may find it easiest to start by rolling the ball into one big hot dog shape.

- Combine 6 parts together, roll them into a ball, and put the ball on Jupiter.
- Combine 3 parts and put them on Saturn.

2. Cut the remaining part into 10 equal parts

- Take 5 parts and combine them with Saturn.
- Combine 2 parts to make Neptune.
- Put 2 parts on Uranus.

3. Cut the remaining part into 4 equal parts

- Take 3 parts and combine them with Saturn.

4. Cut the remaining part into 10 equal parts

- Put 2 parts on Earth.
- Put 2 parts on Venus.
- Take 4 parts and combine them with Uranus.

5. Combine the remaining 2 parts and cut into 10 equal parts

- Put 1 part on Mars.
- Take 4 parts and combine them with Neptune.
- Take 4 parts and combine them Uranus.

6. Cut the remaining part into 10 equal parts

- Put 7 parts on Mercury.
- Take 2 parts and combine them with Uranus.

7. Cut the remaining part into 10 equal parts

- Take 9 parts and combine them with Uranus.
- Put 1 part on Pluto.

Appendix B: Planetary Placemat (sample)

MERCURY	VENUS	EARTH
MARS	JUPITER	SATURN
URANUS	NEPTUNE	