5E Lesson Plan

Lesson Title: Types of Stars & Goldilocks Zone (Explore/Explain 2)

Unit/Theme: Astronomy - Exoplanets

Subject/Grade Level: 9th/10th grade Earth & Space Science

Time Needed: 2-3 full class periods (45 min. each - designed for remote learning)

Driving Question(s)

- What is the Goldilocks zone?
- Which type(s) of star(s) would be the best candidates for having habitable, Earth-like planets orbiting them?
- How does orbit shape and location affect if an exoplanet can be habitable?

NGSS Performance Expectations working toward:

- **HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.**
- **HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements**
- **HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system**

Learning Objectives

I can explain what the Goldilocks (habitable) zone is and why it is important.

I can describe the best orbit shape in order for a planet to be habitable.

I can categorize different types of stars based on shared characteristics.

I can predict which stars would be the best candidates for having habitable, Earth-like exoplanets orbiting them.

Prior Student Knowledge

At this point in the unit students understand how the Sun produces heat and light energy through nuclear fusion and that different elements are created through this process. Students understand that eventually the Sun will run out of fuel and how the Sun is critical for life on Earth. Students also understand the concept of exoplanets and that there are many different galaxies with other stars and exoplanets orbiting those stars in the universe.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematical and Computational Thinking Use mathematical or computational representations of phenomena to describe explanations. (HS-ESS1-4) **Constructing Explanations and Designing Solutions** Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS1-2) Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. **Engaging in Argument from Evidence** Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence. **Obtaining, Evaluating, and Communicating Information** Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex	**ESS1.A : The Universe and Its Stars** The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1) Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-2), (HS-ESS1-3) **ESS1.B: Earth and the Solar System** Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4)	**Patterns** Empirical evidence is needed to identify patterns. **Scale, Proportion, and Quantity** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1) Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth v s. exponential growth). (HS-ESS1-4) **Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable.

evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. Communicate scientific ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-ESS1-3) **Analyzing and Interpreting** Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.		

Common Core State Standards Connections:

Math:

MP.2 Reason abstractly and quantitatively. (HS-ESS1-1), (HS-ESS1-3), (HS-ESS1-4)

MP.4 Model with mathematics. (HS-ESS1-1), (HS-ESS1-4)

HSN-Q.A .1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS1-1), (HS-ESS1-4)

HSN-Q.A .2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1-1), (HS-ESS1-4)

ELA/Literacy:

CCSS.ELA-LITERACY.WHST.9-10.1 Write arguments focused on discipline-specific content

CCSS.ELA-LITERACY.WHST.9-10.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS1-3)

CCSS.ELA-LITERACY.RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.

CCSS.ELA-LITERACY.RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (HS-ESS1-1), (HS-ESS1-2)

CCSS.ELA-LITERACY.RST.9-10.2 Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text. (HS-ESS3-5)

CCSS.ELA-LITERACY.RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.

CCSS.ELA-LITERACY.RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

CCSS.ELA-LITERACY.SL.9-10.1 Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9-10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.

CCSS.ELA-LITERACY.SL.9-10.4 Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task. (HS-ESS1-3)

Possible Misconceptions:

Students often misinterpret the H-R Diagram to show the physical position of a star in space as opposed to as a graphical representation of a star's characteristic at a specific lifestage. Additionally, students often struggle to distinguish between what a star's color tells us about is temperature from what they have already learned about redshift and blueshift and mistakenly believe that a red dwarf star is red because of redshift as opposed to the star's low temperature. Students also struggle with the vocabulary for eccentricity and frequently believe the term 'ellipse' to be a synonym for circular as opposed to oval. Since Earth's orbit is technically an ellipse, students sometimes get confused and believe that it is important for a star's orbit to be elliptical, when in fact the eccentricity of Earth's orbit, 0.017 signifies that it is nearly circular, a critical characteristic for planet habitability. Students often reference the seasons as evidence of Earth's orbit being elliptical.

Differentiation of Instruction:

This lesson includes multiple opportunities for students to engage with the same information through mini-lessons, Edpuzzle videos, and Newsela articles. Embedded questions in the Edpuzzle questions prompt students to self-assess their comprehension and the Newsela articles are assigned at the students' demonstrated reading level. Jamboard discussion & brainstorm activities as a scaffold for students who are unsure to learn from their classmates. The learning activities are designed for students to collect the scientific information they need in order to complete the CER Scientific Explanation in the Evaluate phase. Students' formative assessments are used to determine which students need additional scaffolds like guiding question and/or sentence starters for the CER Scientific Explanation.

Lesson Procedure:

<table>
<tr><th>5E Model</th><th>5E Objectives</th></tr>
<tr><td><u>Engage</u>

Introduce the lesson with an anchoring phenomenon. Facilitate student questions, discussion, etc. as appropriate. Learn about what students already know and want to know.</td><td>Guiding Questions: What orbit shapes exist in our solar system?

Procedure:
- Jamboard Discussion (7): Compare the SHAPES of the orbits for the different planets.
- Project image showing the different orbit shapes in our solar system.

Pre-assessment: What shape orbit do you believe Earth travels on around the Sun? (ascertain students' prior knowledge of orbits in our solar system)

Resources: Image of Solar System orbits OR Image of Solar System orbits (dwarf planets)</td></tr>
<tr><td><u>Explore</u>

Plan for students to engage in hands-on activities that are designed to facilitate conceptual change.</td><td>Guiding Questions: How would a very elliptical orbit affect the characteristics of Earth?

Procedure:
- Watch Video: What If Earth Had a Large Elliptical Orbit
- Prompt students to jot down as they watch the video:
1. How would a very elliptical (oval) orbit affect the characteristics of Earth?
2. Would humans be able to survive? Why?
3. Describe the characteristics of an orbit required for an exoplanet to be habitable.

- Jamboard Discussion (8):
1. How would a very elliptical orbit affect the characteristics of Earth?
2. Would humans be able to survive? Why?
3. Describe the characteristics of an orbit required for an exoplanet to be habitable.

Independent Learning Activity & Formative Assessment:
- Edpuzzle Video: Watch the assigned video "Goldilocks Zone" (2:32) and answer the multiple choice questions in the video.
- REVIEW what you now know about (1) the Sun, (2) how the Sun works, (3) Earth's orbit around the Sun and (4) the concept of the Goldilocks (Habitable) Zone from this week's Learning Activities and class discussions. Using what you know, brainstorm and describe 3 CRITERIA that we need to consider in our search for a habitable exoplanet.</td></tr>
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<u>Explain</u> *Facilitate opportunities for students to explain their understanding of concepts and processes and make sense of new concepts.*	**Guiding Questions:** ● What are the characteristics of our star, the Sun? ● How are different stars similar to and different from our Sun? **Procedure:** - Define eccentricity & ellipse - Review the eccentricity data for the planets in our solar system - Use the [Interactive virtual H-R Diagram] to identify important characteristics of stars including temperature, luminosity, color, mass, and age (life stage) - Mini-lesson on the axes & scales of the H-R Diagram, identify the main groups of stars on the diagram and the Sun - Differentiate between the Life stages for low and high mass stars **Independent Learning Activity & Formative Assessments:** - Edpuzzle Video: Watch the assigned video “Types of Stars” (2:06) and answer the multiple choice questions in the video. Replay any sections if you are stuck on the questions. - Edpuzzle Video: Watch the assigned video “Main Sequence stars” (3:57) and answer the multiple choice questions in the video. Replay any sections if you are stuck on the questions. In your own words, describe the important characteristics of our Sun based on the information in the Edpuzzle video and our class discussion. (minimum of 4 characteristics of our Sun, summarized in at least 3 complete sentences) - Newsela Article: Read the assigned article about the discovery of a new exoplanet called Ross 128 b, Answer the four multiple choice comprehension questions at the end in the Newsela Quiz, & Summarize the main idea of the article in the box below. In your own words, what is the main idea of this article? What are the characteristics of the star and exoplanet that have made scientists excited? (Summarize in 3 - 4 complete sentences. You should not use quotations in your summary, but summarize the important ideas in your own words.) **Additional Formative Assessment:** Kahoot or Nearpod/Pear Deck quiz assess students’ understanding of the characteristics of different star types including red dwarf stars, main sequence stars, neutron stars, red and blue giants, white dwarfs, black dwarfs and supernovae
<u>Elaborate</u> *Provide applications of concepts and opportunities to challenge and deep ideas; build on or extend understanding and skills.*	**Guiding Questions:** How do the life stages of low and high mass stars compare? **Procedure: Star in a Box Activity** **Description:** This simulation visualizes the changes in mass, size, brightness, and temperature throughout the lifecycle of a star. The goal of using this simulation is to help you understand the fate of stars based on their initial (starting) masses.

Objective: I can determine the relationships between the initial mass of a star and its lifespan.

Directions:

1. **Open** “Star in a Box” from: http://starinabox.lco.global/
2. **Click** “Open the lid” of your ‘Star in a Box.’
3. On the right panel, you have data about **five characteristics** of your star.
4. **Hover** (hold your mouse) over each of the five characteristics to determine what they are.
5. **Play** around with the simulation for a few minutes and make some observations.
6. **Make a prediction.**

1. Prediction: Do stars with different masses have a similar lifespan? What do you expect?
Your response:

7. Click the **Data Table** tab you see on the right to open the Data Table for each star.
8. Add up the amount of time each star spent in active phases to **calculate the lifespan of the star**. As an example, the lifespan of a star with 1 solar mass has already been calculated for you below.

1 Solar mass star and above (Low/medium mass)	**10 Solar mass star (High mass)**	**40 Solar mass star and above (Very High mass)**
8,992.81 million years +1,077.05 million years --------------------------------- 10,069.86 million years ***Note:*** *The last row, “A very long time,” is the star’s last stage. It is considered to be inactive or ‘dead’ in this stage.*		

	9. Look back at the **prediction** you wrote for question #3 above. **2. Did the data for the stars' lifespans above support or refute your prediction? Explain.** **Your response:** **Formative Assessment:** Question 2 in the activity above
Evaluate *Assess students' knowledge, skills and abilities.*	**Guiding Questions:** Which type(s) of star(s) would be the best candidates for having habitable, Earth-like planets orbiting them? **Formative Assessment: CER Scientific Explanation for Scientific Question:** Based on our current knowledge, what should we look for in order to find habitable exoplanets in the Universe? Consider the characteristics of stars, orbits and exoplanets that help prove your claim. Students receive specific, actionable feedback on their CER in order to improve their science writing skills and to clarify any content misconceptions in preparation for the unit summative assessment. Students have the opportunity to revise this CER formative assessment in order to demonstrate a higher mastery score. **Procedure:** *(Student Directions Below - Assessment posted on Google Classroom)* **1.** Use the scientific evidence you have collected from our learning activities this unit (this week and previous weeks) and our class discussions to write a claim & evidence paragraph that answers the question: **Based on our current knowledge, what should we look for in order to find habitable exoplanets in the Universe? Consider the characteristics of stars, orbits and exoplanets that help prove your claim.** **2.** Your claim is your answer to the scientific question. **3.** You should support your claim with **a minimum** of **four** pieces of scientific evidence and note where you gathered the evidence from. The more evidence and detail the better! In order to thoroughly answer the question you would need to write **at least** 6 complete sentences. You may need to write two paragraphs to completely explain your evidence and connect your evidence to your claim using scientific reasoning. **Modifications:**

	• **Important vocabulary to consider using in your paragraph(s):** Sun, Earth,star, main sequence, red dwarf, giant, fusion, energy, light, heat, luminosity/brightness, temperature, mass, color, galaxy/galaxies, exoplanet, orbit, circular, elliptical/eccentric/oval, habitable zone/Goldilocks zone • Students are able to use their previous learning activities as resources for their scientific evidence and reasoning

Mastery Skill Rubrics

Visual Interpretation **I can identify, interpret, apply and synthesize relevant information presented visually.**			
Professional (4)	***Practitioner (3)***	***Apprentice (2)***	***Novice (1)***
I can synthesize the relevant information with outside knowledge to address a question or solve a problem.	I can accurately identify, interpret and apply relevant information presented visually (in a chart, graph, diagram, image, etc.).	I can identify relevant information and make basic interpretations of the relevant information presented visually (in a chart, graph, diagram, image, etc.).	I can identify relevant information related to a question or problem.

Claim & Evidence **I can state a detailed claim to answer a scientific question and provide relevant and sufficient scientific evidence to support that claim.**			
Professional (4)	***Practitioner (3)***	***Apprentice (2)***	***Novice (1)***
States specific, detailed claim regarding complex relationships that accurately and completely answers the scientific question. AND Supports claim with extensive relevant and varied scientific evidence.	States detailed claim that accurately and completely answers the scientific question. AND Supports claim with sufficient relevant scientific evidence.	States basic claim that answers the scientific question. AND Supports claim with some appropriate, but insufficient scientific evidence; may include some inappropriate evidence.	States basic claim that answers part of the scientific question; may provide non-scientific or unrelated evidence.

Scientific Communication **I can clearly, accurately, and completely communicate scientific ideas using scientific language.**			
Professional (4)	***Practitioner (3)***	***Apprentice (2)***	***Novice (1)***
Fluently and accurately communicates complex scientific information or ideas in a professional manner with consistent scientific language.	Clearly and accurately communicates detailed scientific information or ideas with consistent scientific language.	Communicates mostly accurate scientific information or ideas with some minor errors in scientific language.	Communicates general scientific ideas that are mostly accurate.

Reflection & Revision **I can revise and improve my own work through reflection and incorporating feedback.**			
Professional (4)	***Practitioner (3)***	***Apprentice (2)***	***Novice (1)***
I can thoroughly revise my own work using the criteria in the mastery rubrics and feedback I receive. I can show detailed evidence of reflection and revision to improve the quality of my work.	I can revise my own work using the criteria in the mastery rubrics and feedback I receive. I can show evidence of reflection and revision to improve the quality of my work.	I can revise parts of my own work using the criteria in the mastery rubrics and feedback I receive. I can show some evidence of reflection and revision to improve the quality of my work.	I can revise parts of my own work using the criteria in the mastery rubrics and feedback I receive.

References

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