Planetary Research Project

Lesson plan for grades 6-11

NGSS standards aligned along with DoD Critical Technologies

Table of contents

Grade Level: 6-11 **Estimated Time needed: Dependent on Activity selection**

What's included in this lesson plan:

- **Core Research Project:** A two-part worksheet that guides students to research Earth and another celestial body, with provided answer sheets for recording findings.
- **Celestial Body List:** A list of planets and moons for students to select for their research.
- **Extension Activities:** Options for students to create a research paper, a slide deck presentation, or a hands-on cross-section model of Earth and their chosen celestial body (with accompanying student worksheet) to deepen their understanding.
- **Prompts and Guidelines:** Specific prompts for comparative analysis, creative thinking, and technology connections for both research papers and presentations.
- **Rubrics:** Detailed rubrics for grading both the research paper and the slide deck presentation based on content, organization, and academic requirements.

NGSS Learning Standards: Middle School

- **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-ESS1-4:** Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.
- **MS-ESS2-1:** Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
- **MS-ESS3-1:** Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

NGSS Learning Standards: High School

- **HS-ESS1-4:** Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
- **HS-ESS1-6:** Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.
- **HS-ESS2-1:** Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.
- **HS-ESS2-3:** Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.
- **HS-ESS3-2:** Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

DoD Critical Technologies Connections

- **Artificial Intelligence:** The core research project requires students to gather, analyze, and interpret planetary data, reflecting how AI processes and accelerates scientific discovery in space exploration. Additionally, the extension lesson's hands-on modeling activity parallels AI-driven simulations that visualize planetary interiors and dynamics.
- **Future Computing Technologies:** Both the research project and the model-building extension rely on computational tools and data analysis, highlighting the vital role of advanced computing in simulating and understanding complex planetary features and processes.
- **Advanced Manufacturing:** The hands-on model building connects to advanced manufacturing techniques such as 3D printing and robotics, which are essential for producing hardware used in space missions as well as educational models.

Estimated time to complete project:

- **Core Research Project (Parts 1 & 2):** 2-3 class periods.
- **Core Project with One Extension:** 1-2 weeks.
- **Comprehensive Lesson with Multiple Extensions:** 3-4 weeks.

Learning Targets: Middle School

- I can identify and describe the structure, atmosphere, and major features of Earth and another celestial body.
- I can compare and contrast Earth with another celestial body using evidence from my research.
- I will construct explanations and models that show how planetary features and processes (such as gravity, geology, or atmosphere) affect each world differently.

Learning Targets: High School

- I can analyze and interpret data about Earth and another celestial body to explain similarities and differences in their features and processes.
- I will evaluate how planetary resources and environmental conditions could affect habitability or support future space exploration.
- I can create and communicate a research-based argument or presentation that uses evidence, models and citations to explain planetary science concepts.

Learning Objective:

Students will investigate and compare Earth with another celestial body in the solar system, analyzing their structures, geological features, atmospheres, and unique characteristics. Through research, data analysis, and creative extension projects, students will construct models, evaluate evidence, and communicate scientific findings to deepen their understanding of planetary science and its connections to space technology, energy, and future exploration.

Planetary Research Project

Name: _____ Date: _____

This worksheet will guide your research about Earth and another *celestial body* in our solar system. You will collect information to create models and compare the two. Use the provided answer sheet to record your findings as you work through the questions.

Celestial Body: A celestial body is any natural object found in outer space. In this activity, you will focus on another planet or a large moon.

Part 1: Earth – Our Home Planet

Let's review the basics of **Earth's structure and composition**. Use your textbook, online resources, or other reliable sources to answer the following questions. Record your answers on the provided sheet.

1. **Composition and Structure:**
    - What are the main elements that make up Earth?
    - Describe the layers of Earth (crust, mantle, inner core, outer core). What are they made of?
    - Draw and label a simple diagram of Earth's layers, showing their relative thickness.
2. **Geological Features:**
    - List and describe some of Earth's most prominent geological features (mountains, valleys, oceans, volcanoes, etc.).
    - Briefly explain how plate tectonics shapes Earth's surface and creates these features.
3. **Atmosphere:**
    - What are the main components of Earth's atmosphere?
    - How does Earth's atmosphere protect life on Earth?
4. **Unique Characteristics:**
    - What makes Earth unique compared to other planets in our solar system? (Think about liquid water, a breathable atmosphere, and the presence of life.)

Name: _____ Date: _____

Part 2: Exploring Another World

Now, you will research ***another celestial body in our solar system*** (other than Earth). Use reliable resources to answer the following questions. Record your answers on the provided sheet.

5. **Composition and Structure:**
    - What are the main elements and compounds that make up your selected celestial body?
    - Does it have layers similar to Earth's? If so, describe them and their composition.
    - Draw and label a simple diagram of your celestial body's layers (if applicable), showing their relative thickness.
6. **Geological Features:**
    - Describe some of the prominent geological features on your celestial body.
    - How did these features form? Are there any ongoing geological processes?
7. **Atmosphere:**
    - Does your celestial body have an atmosphere? If so, what is its composition and density?
    - How does the atmosphere (or lack thereof) affect its surface?
8. **Unique Characteristics:**
    - What are some unique or interesting characteristics of your celestial body?
    - How does it compare to Earth? What are the key differences?

Extension Questions:

1. How do scientists and engineers use remote sensing and robotic probes to study the geology of other planets?
2. How might the resources available on your chosen celestial body be valuable for future space exploration or the development of advanced materials?

Planetary Research Project Answer Sheet

Name: _____ Date: _____

Use this sheet to record your answers as you work through the worksheet. Be clear and complete in your responses and include diagrams where requested. This sheet will help organize your research so you can compare Earth with your chosen *celestial body* later.

Celestial Body: A celestial body is any natural object found in outer space. In this activity, you will focus on another planet or a large moon.

Part 1: Earth – Our Home Planet

1. Composition and Structure:

2. Geological Features:

3. Atmosphere:

Name: _____ Date: _____

4. Unique Characteristics:

Part 2: Exploring Another World

5. Composition and Structure:

6. Geological Features:

7. Atmosphere:

Name: _____ Date: _____

8. Unique Characteristics:

Extension Questions:

1. How do scientists and engineers use remote sensing and robotic probes to study the geology of other planets? Be sure to answer in complete sentences.

2. How might the resources available on your chosen celestial body be valuable for future space exploration or the development of advanced materials? Be sure to answer in complete sentences.

Name: _____ Date: _____

Bibliography

Example Resources You Can Use:

- NASA Solar System Exploration: solarsystem.nasa.gov (Excellent overall resource)
- National Geographic: nationalgeographic.com (Engaging articles and visuals)
- Planetary Society: planetary.org (Focus on space exploration and advocacy)
- NASA Planetary Photojournal: photojournal.jpl.nasa.gov (Stunning images)
- Wikipedia (use with caution, emphasize verification with other sources): wikipedia.org

Sources Used (Bibliography)

Be sure to list all sources you used for this project. Include websites, books, articles, or videos.

Example Formats:

MLA Style

- *Website: Author (if listed). "Title of Webpage." Website Name, Publisher, Date, URL.*
  - *Example: NASA. "Mars Exploration." NASA Solar System Exploration, NASA, 2025, https://solarsystem.nasa.gov/planets/mars/overview.*
- *Book: Author Last, First. Title of Book. Publisher, Year.*
  - *Example: Tyson, Neil deGrasse. Astrophysics for Young People in a Hurry. Norton, 2019.*

APA Style

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Bibliography continued

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    - *Example: NASA. "Mars Exploration." NASA Solar System Exploration, NASA, 2025, https://solarsystem.nasa.gov/planets/mars/overview.*
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Example: Tyson, N. deG. (2019). Astrophysics for young people in a hurry. Norton.

Celestial Bodies for Student Research

Planets	Moons
Mercury	No true moons
Venus	No true moons
Mars	Phobos and Deimos
Jupiter	Lo, Europa, Ganymede and Callisto
Saturn	Titan, Enceladus, Mimas and Rhea
Uranus	Mirana, Titania, Oberon and Proteus
Neptune	Triton, Despina, Galatea, Halimede and Hippocamp

Note: Not all moons are listed for all planets

Instructor Guide: Extension Activities

On the following pages, you will find writing prompts, slide deck prompts with guidelines, and corresponding rubrics. These extension activities are designed to deepen students' understanding of Earth and other celestial bodies while providing opportunities to apply knowledge in creative and analytical ways.

Implementation Options:

- **Student Choice Option:** Allow students to select their preferred format (slide deck or written paper) and the prompt that interests them most. This approach increases engagement through personal investment in the topic.
- **Instructor-Assigned Option:** Assign specific formats and prompts based on your assessment of student needs, classroom objectives, or to ensure coverage of key planetary science concepts.

Suggested Formats:

- Individual projects
- Collaborative small-group work
- Whole-class investigations, with different groups exploring different aspects
- Homework assignments to reinforce classroom learning

These materials are flexible resources that support your teaching goals while challenging students to think deeply about planetary science concepts.

Research Paper Prompts:

Combined Comparative Analysis Prompt:

- "Write a comparison paper about Earth and your other celestial body. Explain their similarities and differences, including details about their physical features, atmospheres, and other important characteristics you've discovered through your research. Use complete sentences, organize your information into clear paragraphs, and be sure to cite all your sources."

Comparative Analysis prompts:

- **Atmospheres and Weather**
  Write about how the atmosphere affects your chosen celestial body compared to Earth. Does your world have clouds, wind, or storms? Why or why not? Explain how the atmosphere (or lack of one) changes the temperature and surface conditions. What would it feel like to stand on this world compared to Earth? Support your ideas with facts from your research.

- **Could Life Exist There?**
  Based on your research, write about whether your other celestial body could support life. What does life need to survive? How many of these things does your world have? Compare these conditions to Earth and explain what makes your chosen world friendly or unfriendly to life as we know it. Conclude with what scientists would need to study further to know for sure. Support your ideas with facts from your research.

Creative Thinking Prompts:

- **Design a Space Mission**
  Design a robot explorer to study your selected celestial body. **Draw and label your robot**, showing what tools and instruments, it would carry. Write a mission plan explaining:
  - Where exactly your robot would land and why
  - What three main things it would study
  - How it would power itself
  - How it would send information back to Earth
  - Explain why your mission would be important for science.

- **Space Colony Challenge**
  Imagine building the first human base on your selected celestial body. Write about:
  - What resources from this world could people use (ice, soil, gases, etc.)
  - Three major challenges humans would face living there
  - How people might solve these problems
  - What the inside and outside of your base would look like **Include a sketch of your base design** and explain why you designed it this way.

Research Paper Prompts:

Technology Connection Prompts:

- **Space Materials Science**
  Research what your selected celestial body is made of. Pick one material or element found there that interests you. Write about:
  - What special properties this material has
  - How this material could be used to create something useful
  - How scientists could collect or mine this material
  - Two ways this material might be valuable on Earth or in space **Include a creative drawing** of your idea for using this space material.

- **Surviving Space**
  Design a spacesuit or habitat for your selected celestial body. Consider the challenges of:
  - Temperature (too hot, too cold, or extreme changes)
  - Radiation from the sun or space
  - The atmosphere or lack of air
  - Gravity differences

Explain how your design protects against these challenges. **Draw and label your design**, showing what materials would be used and why they would work in this environment

Slide deck presentation Prompts:

General Presentation:

- "Create a presentation comparing Earth and your selected celestial body. Include slides that examine physical characteristics, atmospheric conditions, and other key features. Use compelling visuals, clear explanations, and proper citations for all sources. Be prepared to present your findings in a 5-7 min presentation.

Topic-Specific Presentation Prompts:

- **Planetary Comparison Presentation:**
  - "Design a presentation that takes us on a visual tour comparing Earth and your selected celestial body. Create slides that show side-by-side comparisons of landscapes, size, orbit, and composition. **Include at least one interactive element (poll, quiz question, or demonstration) to engage your audience.** Cite your sources and be prepared to present your findings in a 5-7 min presentation."

- **Space Mission Briefing:**
  - "Develop a mission briefing presentation for exploring your selected celestial body. Include slides covering the mission objectives, landing site with justification, equipment needed, and expected discoveries. Use diagrams, maps and images to illustrate your mission plan. End with a slide explaining how this mission would expand our scientific knowledge. Cite your sources and be prepared to present your findings in a 5-7 min presentation."

- **Habitability Analysis:**
  - "Create a presentation analyzing whether your selected celestial body could support human life. Assess factors like temperature, atmosphere, water availability, and radiation levels. Use charts, graphs, or comparison meters to visually compare these conditions to Earth's. Conclude with recommendation slides detailing what would be needed to make this world more habitable. Cite your sources and be prepared to present your findings in a 5-7 min presentation."

Name: _____ Date: _____

Slide deck presentations Guidelines:

For slide presentations, please follow these specific requirements:

- ☐ **Include a title slide** with your name, date, and topic
- ☐ **Use 8-12 content slides** (not including title and bibliography slides)
  - Hide the bibliography slide during your presentation (but include it in your submitted file)
- ☐ **Include at least 5 relevant images or diagrams** and tell where you got them
  - For each image, add a small note saying where it came from (like "Image: NASA, 2022")
  - This shows that you didn't just take someone else's work without giving them credit
- ☐ **Use bullet points rather than paragraphs**
  - Keep text short and easy to read
  - Aim for 3-5 bullet points per slide
- ☐ **Include at least one chart, graph, or table** that compares Earth to your selected celestial body
  - Make sure it has a clear title and labels
  - It should help viewers see differences or similarities easily
- ☐ **End with a concluding slide** summarizing key similarities and differences
- ☐ **Prepare speaker notes** for each content slide
  - Write down what you'll say about each slide
  - Include extra details that aren't on the slide itself
  - Be prepared to speak for 5-7 minutes

***Remember: Your slides should help with your presentation, not be your entire presentation. Use pictures and simple text to support what you're saying.*

Name: _____ **Date:** _____

Earth Vs. Other Celestial Bodies: Research Paper Rubric

Content (40 points)

CRITERIA	EXCELLENT (8-10 PTS)	SATISFACTORY (5-7 PTS)	NEEDS IMPROVEMENT (0-4 PTS)
Scientific Accuracy	Information is accurate and demonstrates thorough research	Information is mostly accurate with minor errors	Contains several inaccuracies or shows limited understanding
Comparison Depth	Detailed, thoughtful comparisons between Earth and chosen celestial body across multiple features	Basic comparisons covering major similarities and differences	Few or superficial comparisons lacking significant detail
Evidence & Examples	Supports claims with specific, relevant examples and data	Provides some supporting examples and evidence	Few examples or evidence to support comparisons
Analysis	Insightful analysis explaining why similarities/differences exist	Basic analysis of similarities/differences	Limited or no analysis beyond stating facts

Organization & Writing (30 points)

CRITERIA	EXCELLENT (8-10 PTS)	SATISFACTORY (5-7 PTS)	NEEDS IMPROVEMENT (0-4 PTS)
Structure	Well-organized with clear introduction, body paragraphs, and conclusion	Basic organization with recognizable beginning, middle, and end	Poor organization; difficult to follow
Paragraph Development	Well-developed paragraphs with topic sentences, supporting details, and transitions	Most paragraphs have clear focus and adequate development	Paragraphs lack focus or consist of undeveloped ideas
Writing Mechanics	Few or no errors in grammar, spelling, and punctuation	Some errors that occasionally distract but don't impede understanding	Numerous errors that significantly impede understanding

Notes:

Name: _____ **Date:** _____

Academic Requirements (30 points)

CRITERIA	EXCELLENT (8-10 PTS)	SATISFACTORY (5-7 PTS)	NEEDS IMPROVEMENT (0-4 PTS)
Required Elements	Addresses all required content areas with comprehensive detail	Addresses most required content areas with adequate detail	Missing several required content areas or minimal detail
Citations	Properly cites all sources using consistent format	Most sources cited with minor formatting inconsistencies	Few/incorrect citations or inconsistent formatting
Overall Quality	Exceptional work showing thorough understanding and critical thinking	Satisfactory work showing adequate understanding	Minimal effort showing limited understanding

Total Points: _____/100

Grading Scale:

- A: 90-100 points
- B: 80-89 points
- C: 70-79 points
- D: 60-69 points
- F: Below 60 points

Comments:

Name: _____ **Date:** _____

Earth Vs. Other Celestial Bodies: Slide Deck Rubric

Content (40 points)

CRITERIA	EXCELLENT (8-10 PTS)	SATISFACTORY (5-7 PTS)	NEEDS IMPROVEMENT (0-4 PTS)
Scientific Accuracy	Information is accurate and demonstrates thorough research	Information is mostly accurate with minor errors	Contains several inaccuracies or shows limited understanding
Comparison Depth	Detailed, thoughtful comparisons between Earth and chosen celestial body across multiple features	Basic comparisons covering major similarities and differences	Few or superficial comparisons lacking significant detail
Evidence & Examples	Supports claims with specific, relevant examples and data	Provides some supporting examples and evidence	Few examples or evidence to support comparisons
Analysis	Insightful analysis explaining why similarities/differences exist	Basic analysis of similarities/differences	Limited or no analysis beyond stating facts

Organization & Writing (30 points)

CRITERIA	EXCELLENT (8-10 PTS)	SATISFACTORY (5-7 PTS)	NEEDS IMPROVEMENT (0-4 PTS)
Slide Structure	Well-organized with clear introduction slides, content sequence, and conclusion	Basic organization with recognizable beginning, middle, and end sections	Poor organization; slides seem randomly arranged and difficult to follow
Visual Design	Professional-looking slides with consistent formatting, appropriate font sizes, and effective use of space	Acceptable slide design with mostly consistent formatting and readable text	Inconsistent or distracting design elements; poor use of space or hard-to-read text
Presentation Mechanics	Few or no errors in spelling and grammar; smooth transitions between slides; logical flow	Some errors that occasionally distract; transitions mostly make sense	Numerous errors that significantly distract; abrupt or confusing transitions between topics

Notes:

Name: _____ **Date:** _____

Academic Requirements (30 points)

CRITERIA	EXCELLENT (8-10 PTS)	SATISFACTORY (5-7 PTS)	NEEDS IMPROVEMENT (0-4 PTS)
Required Elements	Addresses all required content areas with comprehensive detail	Addresses most required content areas with adequate detail	Missing several required content areas or minimal detail
Citations	Properly cites all sources using consistent format	Most sources cited with minor formatting inconsistencies	Few/incorrect citations or inconsistent formatting
Overall Quality	Exceptional work showing thorough understanding and critical thinking	Satisfactory work showing adequate understanding	Minimal effort showing limited understanding

Total Points: _____/100

Grading Scale:

- A: 90-100 points
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Comments:

Extension Lesson: Building Planetary Cross-Section Models

Lesson Overview:

Students will build physical models of **Earth** and the **celestial body they have been studying**. Each model will include internal layers (crust, mantle, outer core, inner core when applicable). Students will then slice open their models to create cross-sections and compare the structures as a visual representation of their research.

Learning Targets:

- I can construct a model of Earth and the celestial body I studied that shows their internal layers.
- I can compare and contrast Earth's structure with that of my celestial body.
- I will use my models as visual evidence to explain my research findings.

Materials (Per student or group):

- **Modeling clay or playdough in at least 4 colors**
- Plastic knives or string (for slicing the model)
- Toothpicks and sticky labels (to mark each layer)
- Paper plates or trays (for workspace)
- Rulers or measuring tape (optional, for estimating scale)
- Chart paper or a comparison worksheet

Optional Alternatives:

- Salt dough (DIY flour, salt, water + food coloring)
- Styrofoam or Paper Mache balls cut in half

Layer Color Assignments:

- **Inner core:** Yellow
- **Outer core:** Orange
- **Mantle:** Red
- **Crust:** Brown or Green

Students can adjust the colors for their celestial body if needed (For example: Icy crust = white/blue, metallic core = gray, etc).

Introduction: (10 min)

- Review Earth's layers (crust, mantle, outer core, inner core) and compare them to the chosen celestial body.
- Ask students: *"How might we show these invisible structures in a way we can see and compare?"*
    - This will lead to the extension lesson: Say to students *"Today we will be creating physical models of our planet Earth, along with the celestial body that you studied. Your research will help guide you on what to include."*

Extension Lesson: Building Planetary Cross-Section Models

Building Models: (30-45 min)

- Students roll and flatten clay to form layers in the assigned order:
    - Small yellow ball = **Inner core**
    - Wrap in orange = **Outer core**
    - Wrap in red = **Mantle**
    - Wrap in brown or green = **Crust**
- Repeat to create a second model of the researched celestial body.
- Once complete, slice both models in half with plastic knives/string to reveal the cross-sections.

Labeling and Observation: (15 min)

- Students insert toothpicks with labels into each layer.
- On a comparison chart, students record:
    - Thickness of each layer (relative)
    - Materials/elements likely found in each layer
    - Key similarities and differences with Earth

Discussion and Reflection (10 min)

- Share findings in pairs or groups.
- Guiding questions:
    - *What does your model show about how Earth is similar or different form your celestial body?*
    - *How do these differences affect surface features, atmosphere, or habitability?*
- Optional: Have students display both of their models side by side for a gallery walk.

Name: _____ Date: _____

Student Worksheet: Planetary Cross-Section Models

Celestial Body Studied: _____

Part 1: Building Earth's Layers

Follow the steps below to build your Earth model. Use the suggested colors, or substitute with others if needed — just make sure each layer is a different color.

1. Roll a **small yellow ball** for Earth's **inner core**.
2. Wrap it in **orange clay** for the **outer core**.
3. Add a thick **red layer** for the **mantle**.
4. Cover with a thin **brown or green layer** for the **crust**.
5. Carefully slice your model in half to reveal the layers.
6. Use toothpicks and labels to mark each layer.

Part 2: Building My Celestial Body

Use your research to decide which layers your celestial body has. Assign colors that make sense (example: icy crust = white/blue, metallic core = gray).

1. Write down the layers you plan to include:
2. Build the model just like you did for Earth — smallest layer in the center, building outward.
3. Slice the model in half and label each layer.

Part 3: Compare Earth and My Celestial Body

Feature	Earth	My Celestial Body: _____
Layers Present	Inner Core, Outer Core, Mantle, Crust	
Number of Layers	Four (4)	
Crust Composition	Rock (continental and oceanic)	
Mantle Composition	Semi-solid rock	
Core	Metallic (iron and Nickel)	
Unique Features	Plate tectonics, liquid outer core	

Part 4: Reflection Questions

Answer in complete sentences.

1. What is one major similarity between Earth and your celestial body?

2. What is one major difference?

3. How do these differences affect conditions on the surface or the potential for habitability?