Educating Space Age Environmentalists: A Kindergarten – High School Standards-Based Curricular Approach

(Aligned to the Next Generation Science Standards for Earth and Space Science)

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Introduction

We have designed this curricular approach to incorporate two complementary goals. With the aid of Extension 1 instructional resources, students learn that orbital space is a valuable natural resource, serving as home to spacecraft providing information and perspective that are essential for scientific understanding and social progress. With the aid of Extension 2 instructional resources, students learn that space debris poses a growing threat to spacecraft and requires us to clean up the space environment before it becomes too dangerous to navigate.

Extension 1: Outer space is a valuable natural resource, serving as home to spacecraft that provide essential information and perspective for understanding Earth's Place in the Universe, Earth's Systems, and Earth and Human Activity.

Extension 1 instructional resources for K – 8 are correlated with standards-based lesson plans aligned with the Next Generation Science Standards for Earth and Space Science. Most of these lessons have been provided and vetted by the National Science Teachers Association (NSTA) at webpage NGSS@NSTA (ngss.nsta.org) and all of them provide suitable entry points for Extension 1 resources. We have designed these resources so as to feature a wide range of spacecraft, including the Fermi and Hubble space telescopes, the International Station, and satellites such as Terra and Aqua. Our instructional materials highlight the distinctive and important contribution each makes to our understanding of Earth's Place in the Universe (ESS1), Earth's Systems (ESS2), or Earth and Human Activity (ESS3). Extension 1 materials also are provided for High School Earth and Space Science.

Extension 2: The growing problem of space debris requires us to clean up the space environment - utilizing new technologies and public advocacy - before it becomes too dangerous to navigate.

Extension 2 instructional resources are correlated with Extension 1 activities. In grades K - 2, students learn there is an orbital junkyard surrounding Earth and it needs to be cleaned up. In grades 3 - 5, they continue to learn about the problem and about potential solutions. Students in grades 6 - 8 participate in technology/engineering design challenges related to assessing competing approaches to Active Debris Removal and protecting astronauts during extravehicular activities. As young citizens, they write advocacy letters to their U.S. Representatives and Senators. High school students further deepen their understanding of the space debris issue and prospective solutions, and are challenged to expand their perspective on sustainability to include a clean space environment as well as a green planet.

Recognizing that classroom instructional time is limited and there are many demands on a teacher's time, the extensions are designed for ready incorporation into teachers' regular, standards-based lessons and efficient teaching. **"Educating Space Age Environmentalists: A Kindergarten – High School Standards-Based Curricular Approach"** is not intended to be a stand-alone curriculum but simply a helpful resource to educate students about an important, yet underappreciated, issue. We encourage and appreciate your feedback at any time.

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Summary Chart

Grade Level	NGSS Performance Expectations	Disciplinary Core Idea/Sub-Idea	Lesson Title	Extension 1 Instructional Focus	Extension 2 Instructional Focus
K – 8					
Kinder-garten	K-ESS2-1. Use and share observations of local weather conditions to describe patterns over time. K-ESS3-2. Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.	ESS2. Earth's Systems Weather and Climate (ESS2.D) and ESS3. Earth and Human Activity Natural Hazards (ESS3.B)	"Severe Weather – Blizzards – Let It Snow!" "Severe Weather – Hurricanes – Tropical Storms Run Amok!"	The Geostationary Operational Environmental Satellite-R Series (GOES-R) provides critical information for weather forecasting, including severe storm watches and warnings that help communities prepare for blizzards and hurricanes.	Students learn that "space junk" is orbiting the Earth and putting satellites at risk. They discuss their ideas for how "space junk" might be cleaned up, draw and color a picture of their design, and make an orbital space debris tabletop display, showing and describing their work to their classmates, in alignment with the Speaking and Listening standards from the *Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects* (Kindergarten – CCSS.ELA – Literacy.SL.K.1).
Grade 1	1-ESS1-1. Use observations of the sun, moon, and stars to describe patterns that can be predicted.	ESS1. Earth's Place in the Universe The Universe and Its Stars (ESS1.A)	"Moon Phases Matching"	The International Space Station provides astronauts with views of the moon that are similar to – but also different from how we see it from Earth, especially with respect to the level of detail.	Students write an opinion piece on the issue of space debris in alignment with the *Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects* (Grade 1 – CCSS.ELA – Literacy.W.1.1) after the reading and discussion of a *Scholastic* article about the 2009 collision of the Iridium 33 and Cosmos 2251 satellites that created over 1000 pieces of trackable debris.
Grade 2	2-ESS2-2. Develop a model to represent the shapes and kinds of land	ESS2. Earth's Systems	"Creating Models of	The Terra satellite's Moderate Resolution Imaging Spectroradiometer (MODIS) provides detailed images of	Students read an article, answer questions based on the "5 W's," and write an informative/explanatory piece about the space

	and bodies of water in an area.	Plate Tectonics and Large-Scale System Interactions (ESS2.B)	Landforms and Water"	geographical features that enhance our ability to map landforms and bodies of water.	debris issue, in alignment with the Grade 2 Reading, Writing, and Speaking & Listening standards from the *Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects.* Students also design space debris bookmarks after reading a *Geronimo Stilton Spacemice* book entitled, *Beware Space Junk!* – and experiencing a pairing of informational and literary text.
Grade 3	3-ESS2-1. Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.	ESS2. Earth's Systems Weather and Climate (ESS2.D)	"My NASA Data Lesson: Climate Graphs"	The Geostationary Operational Environmental Satellite-R Series (GOES-R) provides data about clouds and weather patterns that are essential to weather forecasting and studying climate change.	Students write an informative/explanatory piece describing how engineers use biomimicry to design space debris removal technologies with the aid of supporting materials from NPR and NASA and in alignment with the *Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects* (Grade 3 – CCSS.ELA – Literacy.W.3.2).
Grade 4	4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.	ESS3. Earth and Human Activity Natural Hazards (ESS3.B)	"Getting the Right Angle on the Story – How Satellites Can Save Lives in a Tsunami"	The Terra satellite's Multi-angle Imaging Spectroradiometer (MISR) helps scientists understand how tsunamis interact with islands and coastlines and assists them in making better predictions about when and where they will strike.	Students write an opinion piece about the importance of tracking space debris, in alignment with the *Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects* (Grade 4 – CCSS.ELA – Literacy.W.4.1), after learning from a NASA article how telescopes track debris. They also listen to a song about garbage men in space and draw a picture of what a space garbage truck might look like.
Grade 5	5-ESS2-2. Describe and graph the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth. and	ESS2. Earth's Systems The Roles of Water in Earth's Surface Processes (ESS2.C) and	"Global Water Distribution"	The Gravity Recovery and Climate Experiment (GRACE) satellites study gravity variations on land masses to provide the most detailed picture available of vital fresh water reserves hidden beneath Earth's surface. The International Space Station's Environmental Control and Life Support System (ECLSS), a water purification component developed for astronauts working in space, is now used to supply	Students write a narrative with the aid of supporting materials from NASA and the Science Channel, in alignment with the *Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects* (Grade 5 – CCSS.ELA – Literacy.W.5.3). Narrative Prompt: *Imagine that you are the commander on board the International Space Station. Suddenly, Mission Control notifies you that you must evacuate immediately, due to the danger of a major collision with a piece of space junk. How do you feel?*

	5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.	ESS3. Earth and Human Activity Human Impacts on Earth Systems (ESS3.C)		clean drinking water to remote and impoverished communities across the globe.	*What do you do next? What happens? What do you learn from this experience? Include details from the NASA article entitled, "What is Orbital Debris?" in your narrative.*
The following grade-specific progression is recommended by protectouterspace.com for grades 6 – 8:					
Grade 6	MS-ESS1-3. Analyze and interpret data to determine scale properties of objects in the solar system.	ESS1. Earth's Place in the Universe The Universe and its Stars (ESS1.A)	"Solar System Scale and Size"	The Hubble Space Telescope is best known for its surveys of the far universe, but it also helps scientists learn more about our own Solar System through its high-resolution images of planets and moons.	Students participate in a spacesuit design challenge aligned with MS-ETS1-3 as they deepen their knowledge about the threat orbital debris poses to spacecraft and astronauts. They work in teams to design spacesuits for their "taternauts" (astronauts in the form of a potato) that provide protection against impacts involving tiny pieces of space debris, and then they test and evaluate their designs.
Grade 7	MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.	ESS2. Earth's Systems The Roles of Water in Earth's Surface Processes (ESS2.C)	"Exploring the Water Cycle"	The Aqua satellite enables scientists to observe the global pattern of water vapor circulation and understand how it connects to the Sun, oceans, atmosphere, and life.	Students participate in a design team project entitled "Engineering Designs for Active Debris Removal" that is aligned with MS-ETS1-2. After learning about ongoing research into several technologies, student teams research the various concepts and report to the class on their respective strengths and limitations.
Grade 8	MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.	ESS3. Earth and Human Activity Human Impacts on Earth Systems (ESS3.C)	"Using the Very, Very Simple Climate Model in the Classroom"	The Aura satellite's measurements of ozone, aerosols, and gases help scientists analyze Earth's atmosphere, including the impact of the Amazon rainforest on its chemical composition.	With the aid of supporting materials in video and written form, and a pre-writing exercise, students participate in a space advocacy letter writing campaign in alignment with *NGSS Appendix M: Connections to the Common Core State Standards for Literacy in Science and Technical Subjects*. Students write one-page advocacy letters to their U.S. Representative and Senators on this topic: What should the United States be doing to clean up the orbiting junkyard in space? Students may also wish to adapt their letters for submission to a local newspaper or other news medium.

High School					
Grade Level	**2016 MA STE Standard**	**Disciplinary Core Idea**	**Title**	**Extension 1 Instructional Focus**	**Extension 2 Instructional Focus**
High School Earth & Space Science	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.	ESS1. Earth's Place in the Universe The Universe and its Stars (ESS1.A)	"Solar Eruptions and Fermi"	Extension 1A. The Fermi Gamma-ray Telescope observes high energy light from solar eruptions on the far side of the Sun, giving scientists a unique tool for understanding solar flares and coronal mass ejections, which can impact electric power transmission and GPS systems.	Extension 2A. Students learn about the importance of orbital traffic control with a NASA video about the near collision between Fermi and a defunct Russian satellite, as described by Fermi project scientist, Julie McEnery.
High School Earth & Space Science	HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.	ESS2. Earth's Systems Earth Materials and Systems (ESS2.A)	"Climate Change and CERES"	Extension 1B. NASA's Cloud and Earth's Radiant Energy System (CERES) is onboard several satellites, measuring reflected sunlight and thermal radiation emitted by Earth and helping scientists understand how the planet's heat budget is changing.	Extension 2B. Students journey from the outer solar system back to Earth with a video from the European Space Agency that gives them a look at the different regions used for spaceflight and explains how debris mitigation and removal measures could preserve future usage of these orbits.
High School Earth & Space Science	HS-ESS3-3. Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity.	ESS3. Earth and Human Activity Human Impacts on Earth Systems (ESS3.C)	"Hunger from Space"	Ext. 1C. The International Space Station's Agricultural Camera (ISAAC) and Terra satellite's Moderate Resolution Imaging Spectroradiometer (MODIS) help American farmers and global policymakers improve agricultural efficiency and address issues related to food security.	Extension 2C. Students are challenged to recognize that orbital space is not a limitless resource in a TED talk by rocket scientist Natalie Panek. Our orbital environment is breathtakingly beautiful and our gateway to exploration, she says, but unless we take responsibility for keeping it that way, the problem of space debris will get worse.