Exoplanet

STEAM (Science / Technology / Engineering / Art / Math)

Middle School - Grades 6 / 7/ 8

Students explore planets orbiting stars outside of our solar system, delve into the origin and evolution of life, and learn how to use the basic functions of the Glenfield Planetarium through project based learning (PBL) during their experience in *Exoplanet*.

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Montclair Public School Elective Overview

Instructional Plan

Course: STEAM: Exoplanet

Marking Period or Trimester: Semester (two marking periods - 1/2 year)

Pacing: # of weeks: 20

NJSLS

Next Generation Science Standards (NGSS):

MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
MS-PS2-4: Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
MS-PS4-3: Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.
MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
MS-LS4-4: Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
MS-LS4-6: Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.
MS-ESS1-2: Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
MS-ESS3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

NJSLS cont.

NJSLS Mathematics:

6.RP.A: Understand ratio concepts and use ratio reasoning to solve problems.
6.NS.C: Apply and extend previous understandings of numbers to the system of rational numbers.
6.EE.C: Represent and analyze quantitative relationships between dependent and independent variables.
6.G.A: Solve real-world and mathematical problems involving area, surface area, and volume.
6.SP.A: Develop understanding of statistical variability.
7.RP.A: Analyze proportional relationships and use them to solve real-world and mathematical problems.
7.EE.B: Solve real-life and mathematical problems using numerical and algebraic expressions and equations.
7.G.A: Draw, construct, and describe geometrical figures and describe the relationships between them.
7.SP.B: Draw informal comparative inferences about two populations.
7.SP.C: Investigate chance processes and develop, use, and evaluate probability models.
8.SP.A: Investigate patterns of association in bivariate data.

NJSLS for English Language Arts (ELA):

R1: Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
R4: Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.
R7: Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.
R8: Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.
R9: Analyze and reflect on how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.
W1: Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
W2: Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.
W3: Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.
W4: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
W6: Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.
W7: Conduct short as well as more sustained research projects, utilizing an inquiry-based research process, based on focused questions, demonstrating understanding of the subject under investigation.
SL1: Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.
SL2: Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.
SL5: Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.

NJSLS cont.
NJSLS for Technology: 8.1.8.A.1: Demonstrate knowledge of a real world problem using digital tools. 8.1.8.A.2: Create a document (e.g. newsletter, reports, personalized learning plan, business letters or flyers) using one or more digital applications to be critiqued by professionals for usability. 8.1.8.A.3: Use and/or develop a simulation that provides an environment to solve a real world problem or theory.
NJSLS for Visual and Performing Arts: 1.1.8.D.1: Describe the intellectual and emotional significance conveyed by the application of the elements of art and principles of design in different historical eras and cultures. 1.3.8.D.1: Incorporate various art elements and the principles of balance, harmony, unity, emphasis, proportion, and rhythm/movement in the creation of two- and three dimensional artworks, using a broad array of art media and art mediums to enhance the expression of creative ideas. 1.3.8.D.2: Apply various art media, art mediums, technologies, and processes in the creation of allegorical, theme-based, two- and three-dimensional works of art, using tools and technologies that are appropriate to the theme and goals. 1.3.8.D.6: Synthesize the physical properties, processes, and techniques for visual communication in multiple art media (including digital media), and apply this knowledge to the creation of original artworks. 1.4.8.A.7: Analyze the form, function, craftsmanship, and originality of representative works of dance, music, theatre, and visual art.

Framing the Learning			
Timeframe	**Big Ideas**	**Essential Questions**	**Enduring Understandings**
Unit 1: The Search for Exoplanets **4 weeks** **(~seven 80 min. periods)**	• Scientists cannot view exoplanets using existing technology. They rely on inductive techniques to find exoplanets. • Exoplanets exist in solar systems with very different characteristics than our solar system. • Scientists use technology such as Earth-bound observatories and orbital telescopes to detect exoplanets. • Scientists use established deductive techniques to determine characteristics of individual exoplanets.	• How do we find exoplanets? • Where are exoplanets located? • What are the characteristics of the exoplanets we have discovered to date?	• Scientists use forms of inductive and deductive reasoning and related techniques to find information. • Science and technology intrinsic to each other. Discovery allows for the development of technology. Technology allows for deeper discovery. • Earth is one of many planets in the Milky Way Galaxy. The Milky Way is one of trillions of known galaxies in the universe.
Unit 2: Exoplanet Environments **3 weeks** **(~five 80 min. periods)**	• Scientists sort exoplanets in categories according to size, temperature, and surface characteristics. • Abiotic factors such as gravity, wind, atmospheric composition, soil (if any) composition, temperature, abundance of water, etc. all shape the surface characteristics of planets. • Satellites (moons) and rings form in a variety of ways and greatly affect the planets they orbit. • Planetary orbits are diverse. Axial tile, rotational and orbital rate, stellar size and class, and planetary class all affect orbit.	• What might it be like to stand (if possible) on the surface of some of the exoplanets? • How do abiotic and physical factors affect the characteristics of planets? • Why do some planets have moons, others have rings, some have both, and some have no satellites? • How does our moon affect life on Earth?	• Every effect in the universe has a cause. • Every object in the universe influences other objects. These influences can be direct or indirect.
Unit 3: Extraterrestrial Life **3 weeks** **(~five 80 min. periods)**	• Life on Earth exists in a variety of environments. Living things evolve in their environment. • Life may exist in different locations in our own solar system. Scientists and engineers from many countries are working together to explore our solar system in the hopes of finding life. • It is probable that life exists on exoplanets having specific environmental and orbital characteristics.	• What form does life take in extreme environments on Earth? • Where might life exist in our solar system other than Earth? How might life forms survive on other planets? • What efforts are being made to study life on other planets in our solar system? Who is doing this work? • How can we make determine if an exoplanet might be capable of supporting life?	• Life is tenacious and highly adaptable. • We will challenge our definition of life as we continue to explore our own solar system. • Scientific pursuits that seem to be driven by sheer curiosity may lead to discovery. Discovery leads to innovation. Therefore, curiosity is immensely important.

Unit 4: Evolution of the Extraterrestrial **4 weeks** **(~seven 80 min. periods)**	• Life evolved on Earth over the course of billions of years. It is a change in allele frequency over time caused by a series of random mutations and reproductive success. • Evolution continues to occur on Earth. There is irrefutable scientific evidence that living things evolve over time. • Evolution, adaptation, and natural selection are related, but not the same. • Living things would evolve on exoplanets, and their evolution would be driven by the same set of factors that affect the evolution of life on Earth.	• How did life start on Earth? Would life have had similar origins on exoplanets? • How does life change over time? What is evolution? What influences the evolution of life forms? • What scientific evidence supports the idea that life forms evolve?	• Life evolves over time. Evolution is directly observable. Species' phylogeny can be traced using techniques employed by modern geneticists. • Evolution is truly random. Life forms do not decide to evolve. Evolution is not directed by any force.
Unit 5: Future Flights to Exoplanets **3 weeks** **(~five 80 min. periods)**	• Engineers are working to develop technology that will allow us to closely study objects outside of our solar system. • Extra-system spacecraft will need to function in a very hostile and unpredictable environment. • Distances between solar systems are vast. Physicists have presented theories that might be used during the development of spacecraft to circumvent distance. • Any spacecraft carrying living passengers will need to be designed to keep a crew alive for, perhaps, multiple generations.	• What kinds of spacecraft are in use today? • How do modern spacecraft function? • What theories have physicists developed that might help us to travel vast distances in space? • What is the environment of space like? What conditions affect spacecraft? • How can we design a space vehicle that might transport a population for a significant length of time?	• Every great human achievement has a starting point. Frequently, the beginning of the process of achievement seems insurmountable. • The individuals who contribute to a project might not see the end result of their work, but their efforts may be critical to the overall completion of a great achievement.
Unit 6: Exoplanet Presentation in the Glenfield Planetarium **3 weeks** **(~ five 80 min. periods)**	• Elements of presentation, such as format, scale, attractiveness, organization, and delivery, influence audience attention and retention. • Developers use digital platforms to create memorable presentations. • Individual efforts throughout this semester are valuable and worthy of showcasing.	• How can software be used to create memorable presentations? • What elements of delivery successfully convey content to an audience? • How can I best represent my work to an audience?	• Audiences respond well to presenters who are genuinely invested in their topic. Lack of interest, organization, or basic understanding of a topic is immediately perceptible to audiences. • Software is not intimidating.

Evidence of Learning	
• **Fulfillment of criteria listed on project-specific rubrics** • **Ability to comfortably discuss topics and work** • **Score comparison between pre and final assessment**	• **Completion of assigned projects** • **Performance during presentation**

Activities	
Unit 1:The Search for Exoplanets	Leading Activities: Exoplanet detection process lab, parallax lab, mapping the discovered exoplanets activity, create a model of a space telescope using cad software. Final Project: Create a model of an exe-system. All exoplanets and star(s) must be represented accurately according to available data.
Unit 2: Exoplanet Environments	Leading Activities: Creating a HR-type diagram/graph of all known exoplanets, abiotic factors lab, create a children's book about the effect of the moon on Earth (What if we had no moon? Two moons? Rings? etc.) Final Project: Create a 3d model of the surface of an exoplanet based on randomly generated abiotic characteristics; Create a surface texture for import into DarkMatter to generate an exoplanet in the Glenfield Planetarium
Unit 3: Extraterrestrial Life	Leading Activities: Protist lab, research project about potential life forms in our solar system resulting in slides Final Project: Create biotic factors that might exist on the exoplanet designed during the "Exoplanet Environments" unit; Create a food web related to designed extraterrestrials
Unit 4: Evolution of Extraterrestrial Life	Leading Activities: Creation of evolutionary lineage chart for species of choice, evolution mock-trial, evolution/adaptation/natural selection game design Final Project: Select one species from project completed during the "Extraterrestrial Life" unit to be the planet's dominant species; Create an evolutionary lineage for this species; Write a children's book about the evolution of this species, create a cad-based model of this species for import into DarkMatter
Unit 5: Future Flights to Exoplanets	Leading Activities: Research project about spacecraft in development resulting in slides, create a "choose your own adventure" type book about traveling to another solar system, create a model of space time capable of demonstrating warping Final Project: Create a model of a craft capable of transporting multiple generations of humans to another solar system over the course of 1000 years
Unit 6: Exoplanet Presentation in the Glenfield Planetarium	Final Project: Create and deliver one part of a presentation about space exploration, exoplanets, and individual exoplanets and species created during this semester in the Glenfield Planetarium using DarkMatter

DIFFERENTIATION			
Special Education	**ELL**	**Intervention**	**Acceleration**
• Modify and accommodate as listed in student's IEP or 504 plan • Prioritize instruction • Utilize wait-time • Ensure directions are clear and concise • Utilize probing and clarifying questions • Support instruction with scaffolding • Model (provide step by step instructions) use of learning strategies • Provide extended time for practice and review of learning strategies • Create rubrics to develop assessments • Vary assessments • Provide individual help to all students • Create opportunities for/Monitor peer collaboration • Monitor student progress frequently • Utilize flexible/cooperative grouping based on instructional goals • Prioritize and chunk lengthy assignments • Utilize assistive technology, when appropriate • Provide ongoing, effective, specific feedback • Model/Utilize graphic organizers • Utilize visual aids and props (flashcards, pictures, symbols) when possible • Utilize a multi-sensory approach to new topics	• Get to know student • Set high expectations • Allow electronic translator • Reword, repeat, and clarify directions • Determine student knowledge and level of understanding • Research instruction that best matches student need • Utilize ongoing informal assessments • Refer to NJDOE Resources: https://www.state.nj.us/education/bilingual/resources/ • NJDOE ELL Support Descriptions: https://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf ***Review Special Education list for additional recommendations.***	• Tiered Interventions following RtI framework • RtI Intervention Bank • Fundations Double-Dose (Tier II) • LLI (Tier III) • FFI Skill Report: DRA On-Line • enVision intervention supports NJDOE resources	• Process should be modified: higher order thinking skills, open-ended thinking, discovery • Utilize project-based learning for greater depth of knowledge • Utilize exploratory connections to higher grade concepts • Contents should be modified: abstraction, complexity, variety, organization • Products should be modified: real world problems, audiences, deadlines, evaluation, transformations • Learning environment should be modified: student-centered learning, independence, openness, complexity, groups varied