Course/Level	6th – 8th Grade		
Topic	Growing seeds in different soil mediums	**Time Frame**	4 to 6 1-hour class periods for the initial lesson and wrap up lesson ; observations / monitoring for 3-4 weeks.

What are the questions or concepts to be investigated?
Concepts to be investigated: data collection, structure of soil vs. sand, investigation of the role of stress on plants that grow in space compared to on Earth, role of soil in plant growth, importance of crop rotation, and lunar regolith. **Questions to be investigated**: What is the difference between soil and sand? How does the stress of a low g environment affect plant growth? What type of soil medium allows plants to grow best? What nutrients do plants need in soil? What nutrients do plants take out of soil?

Objectives, NGSS & Common Core State Standards Connections	**List of Materials:**
Teacher objective: For students to construct an experiment to test how different soil combinations affect plant growth and to compare plant growth in a 1 g environment with plant growth on the International Space Station. **Student objective:** Construct an experiment to test which soil mixture is most successful in growing a variety of plants and compare plant growth in the 1 g environment in the ExoLab Growth Kit and the microgravity environment of the International Space Station.	Student device that can access the internet. Projector for teacher use. Pictures of lunar regolith. LED grow light strongly recommended. ExoLab Growth Kit ExoLab Teacher Advanced Supply Kit ExoLab Ticket to Space – Student Kit Playground sand and potting soil, (if feasible lunar regolith simulant may be purchased to use instead of playground sand. Note that lunar regolith simulant can be expensive and require additional PPE for students when handling.) A variety of seeds for students to select for their experiment. Each group will need 12 total seeds, 6 of one type and 6 of another type. Seeds / materials provided by ExoLab in the Ticket to Space and Advanced Supply Kit. Containers to grow seeds – 6 containers per group – 4 for experimental soils and 2 for the control soil. Measuring cups to calculate volume of both potting soil and playground sand. Scale to measure exact weights soils after combining. Ruler to measure plants as they grow.
NGSS Standards: MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services. MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. **Common Core State Standards:** ELA / Literacy-	

SL.8.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details. SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest Mathematics- 6.SP.4 Summarize numerical data sets in relation to their context.	

Prior Knowledge Requirements
Knowledge of photosynthesis, and what seeds need to grow.

5E Descriptions
Engage (15 min.) Show students pictures of Moon regolith and have students touch physical samples of playground sand and potting soil. Show a short video of astronauts working on the International Space Station with an ExoLab CubeLab (https://magnitude.io/exolab-9/). Start a conversation asking students what they notice about the physical structure (both similarities and differences) between all the sample soils. Ask students what they wonder and what they notice as Astronaut Shannon Walker removes the ExoLab CubeLab on the ISS. Tell students that when astronauts go to the Moon or Mars they will have to figure out how to feed their crew since they are not able to bring all of their food with them. Astronauts will also need to grow plants as they travel to Mars and use regolith once they land on either the Moon or Mars as a soil additive since they will not be able to bring all of the necessary soil with them to grow plants and food. Build rubric shared with students to use as a guideline for the project.
Explore (120 min.) 2 60-minute class periods Students will research regolith, soil, and the importance of soil by reading the following articles: (https://www.britannica.com/science/regolith) (https://www.britannica.com/summary/soil) (https://www.isric.org/discover/about_soils/why-are-soils-important#:~:text=Soil%20provides%20plants%20with%20foothold,against%20pollutants%2C%20thus%20protecting%20groundwater) Students will then use what they learned in the articles to formulate a hypothesis and questions to design an experiment that will test how soil makeup affects plant growth. Students will construct an experiment using a ratio of playground sand (to represent lunar regolith) and potting soil. Students must use at least 50% (by volume) of playground sand in their soil mixture for each of the two experimental soils. Students will select two different types of seeds and create two different types of soil mixtures to conduct an experiment on how soil makeup affects plant growth. Students will also plant their selected seeds in 100% potting soil for a control.

Students will design, measure, and plant their seeds in their selected soil mixtures: two containers for one soil mixture, two containers for another soil mixture, and two containers as controls.

Each group of students will have a total of six containers, two seeds per container (six of each type of seed) for their experiments. For example, if students select corn and beans to grow, two corn seeds will be planted in each of the three containers, one representing soil mixture A, one representing soil mixture B, and one representing the control. The six bean seeds will be planted in the remaining three containers, two per container. Each container should be weighed after being planted.

All containers should receive the same amount of water (students can decide how many mL of water) and the same amount of light. An LED grow light is recommended.

For the seeds / plants grown in the ExoLab CubeLab, students will follow the experiment as presented by ExoLab for the ExoLab experiment.

Explain (60 min.)

To be conducted after a one-week growing period. During the growing period students should take daily notes on their plants and record their findings (plant growth, (about five minutes per day). They should observe both the plants they planted in lunar regolith and potting soil, and the plants growing in the ExoLab CubeLab.

Students will share the hypothesis for their experiments and what they learned with their classmates via Flipgrid. Students will share what they thought would happen in their experiment with what actually is happening and come up with reasonable explanations.

Students will continue to conduct their experiment for an additional week. If no seeds have sprouted, students will have the chance to reevaluate their experiment and make changes.

Elaborate (60 minutes)

Students will learn about the importance of crop rotation by watching a short video on ***"What is Crop Rotation?"*** https://www.youtube.com/watch?v=O9YDlcKG4rA and read https://learninglab.si.edu/q/ll-c/mAnLejoKapqTClxN#r/1002612 . Students will reflect how astronauts will use crop rotation on the Moon or on Mars in gardens. Students will also use their knowledge of growing plants in different soil mediums to draw a conclusion on how they would use crop rotation if they carried out their experiments in their soil mediums for another season.

Students will access data from the ExoLab mission on the ISS and compare and contrast it to the data they collected with their ExoLab.

Students will explain their final experiment results showcasing their data collection and final outcomes through their choice of options: photo journal with notes, video, written report, or another means of media to present after consulting with the teacher.

Evaluate (30-60 minutes)

Students will present their findings from the elaborate stage to their classmates in a gallery style walk. As students view their peers work they will fill out the rubric created in the engage stage for fellow students and one for themselves.

Students will evaluate final findings from the ISS ExoLab CubeLab mission and compare and contrast it to the data they collected.

A successful project does not necessarily mean that all of the seeds will have germinated as long as students can elaborate on their findings.

Additional Resources :

ExoLab by Magnitude.io
"Investigate the effects of microgravity on living things"
https://magnitude.io/exolab/

University of Minnesota Bell Museum – biodiversity of MN atlas
https://www.bellmuseum.umn.edu/

What is Lunar Regolith?
https://curator.jsc.nasa.gov/lunar/letss/regolith.pdf

Lunar Regolith Simulants – Exolith Lab:
https://exolithsimulants.com/collections/regolith-simulants

Vegetable Crops that do not need Pollinators
https://www.hortmag.com/edible-gardening/vegetable-crops-that-do-not-need-pollinators