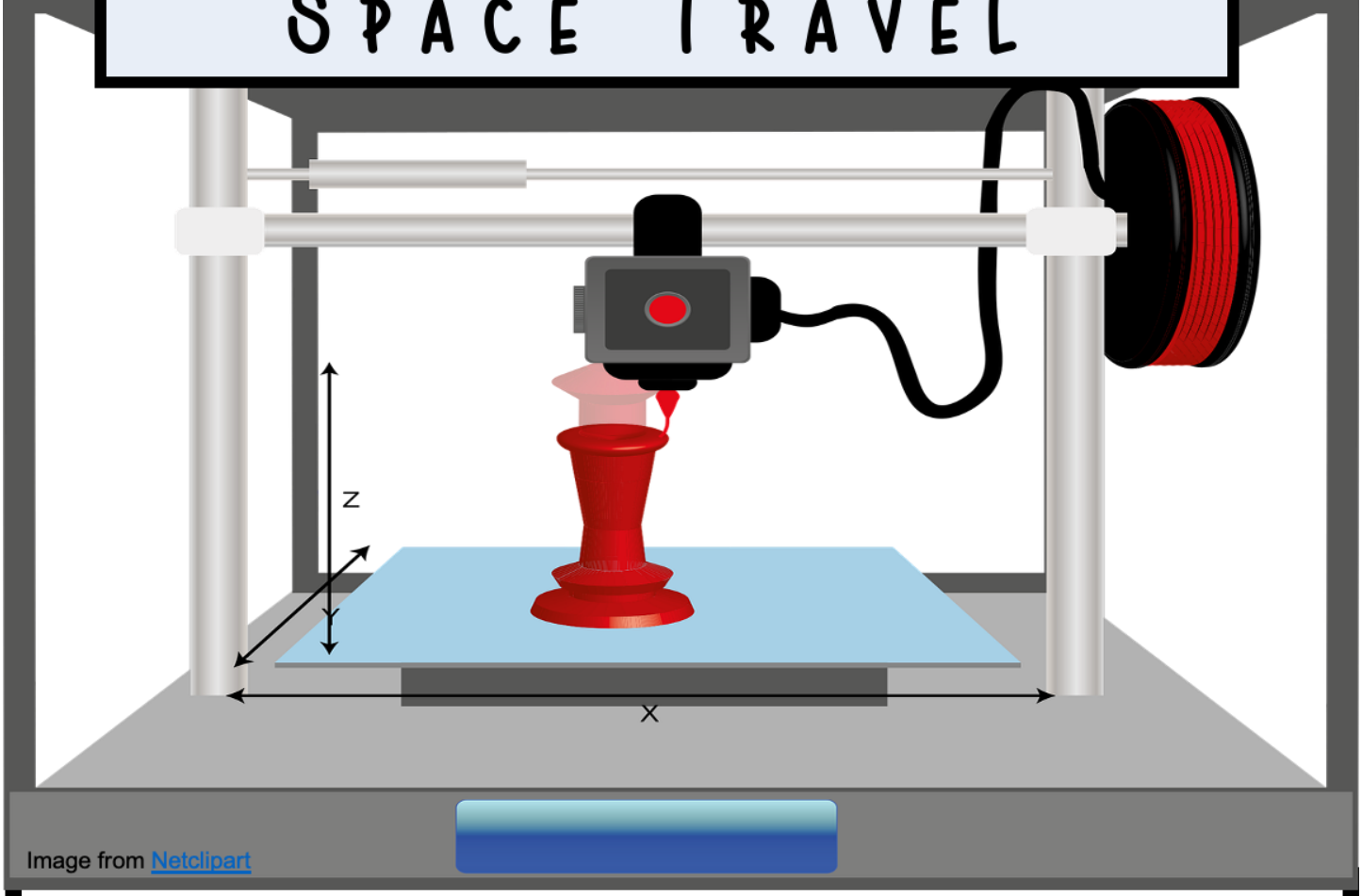
Engineering Design Process

Solutions for Space Travel



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UNLV | Howard R. Hughes College of Engineering

Nevada STEM Networks

Tech Trekker Powered by: UNLV Engineering

On the move... Bringing technology into classrooms

This material was supported by funding from NV STEM Networks and is affiliated with the UNLV College of Engineering's Tech Trekker program.

Contents

Engineering Design Process: Solutions for Space Travel Overview

Introduction: This unit explores the Engineering Design Process through the phenomena of living in space and space travel. Students will explore 3D printing applications for space travel and exploration. They will learn how to design 3D objects, and will apply that knowledge to engineer solutions to space travel problems. After using the Engineering Design Process, students will print their solutions using the 3D printers. Then they will review their creations to improve on their first iteration and print out a second, updated iteration.

This unit should take approximately 3-4 weeks depending on pacing and classroom needs. **It is suggested that the unit be implemented at least several months into the school year.**

This UNLV Tech Trekker kit is able to be used for up to 3 days. It is recommended that the Tech Trekker team comes once during Activity 2 and twice during Activity 3. The Tech Trekker team can come throughout the day on each of these days. This will allow teachers to share the lesson with their entire grade level, so all classrooms have access to the 3D printer.

Recommended Plan for Unit:

- **Activity 1:** Students will conduct research on 3D printers and how these devices have impacted space travel and exploration. While researching, students will be engaged in several ELA reading and writing activities: reading current articles, developing essential questions, and stating opinions with specific details and examples. In the end, students will complete a multimedia visual aid supporting the claim that 3D printers are necessary in space. Suggested Time: 5 hours over various days
- **Activity 2:** Students will explore the web-based CAD program, Tinkercad, as they complete a series of modules to learn all the mechanics and tools needed to design and build 3D images. This activity is self-paced, provides student choice, and the content can be adjusted based on the readiness of students. A scoring rubric and checklist are provided to help students stay on track, and for teachers to monitor their learning. Suggested Time: 5 hours over various days
- **Activity 3:** Students will use the knowledge gained in the first two activities to explore deeper into what 3D objects could be useful in space. Students will apply knowledge by identifying a problem in space and working through the Engineering Design Process to create a solution to the identified problem, then print it out using the 3D printer. Suggested Time: 5 hours over various days

Timing Recommendations

- Complete Activity 1 (research project) and Activity 2 (Tinkercad) simultaneously. Activity 1 can be completed during the ELA block and Activity 2 can take place during the science block.
- Collaborate with the Humanities, STEM, and Librarian teachers to co-teach the unit.
- Activity 1 can be abridged based on the time, readiness, and needs of the classroom/students.
- While items are being printed during Activity 2 by Tech Trekker, begin Activity 3.

Acknowledgements:
Lessons were created by Teresa O'Shea, Christy Simon, and Trulie Cottman, with support from Dr. Erica Marti and Paul Oko.

Standards

Grades 3-5

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

SEP-1. Asking Questions and Defining Problems

SEP-5. Using Mathematics and Computational Thinking

SEP-6. Constructing Explanations and Designing Solutions

SEP-8. Obtaining, Evaluating, and Communicating Information

CCC-2. Cause and Effect: Mechanism and Explanation

CCC-3. Scale, Proportion, and Quantity

CCC-6. Structure and Function

(3-5)P.3. Demonstrate elements of art.

(3-5)P.15. Use digital media and techniques to create a work of art.

Grade 3 Specific

RI.3.1. Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.

RI.3.2. Determine the main idea of a text, recount the key details and explain how they support the main idea.

RI.3.3. Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.

RI.3.7. Use information gained from illustrations (e.g., maps, photographs) and the words in a text to demonstrate understanding of the text (e.g., where, when, why, and how key events occur).

W.3.1b. Provide reasons that support the opinion.

W.3.7. Conduct short research projects that build knowledge about a topic.

W.3.8. Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.

SL.3.2. Determine the main ideas and supporting details of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.

3.EL.A.1. Independently utilize digital and non-digital planning tools.

3.ID.A.1. Explore and practice how a design process works to generate ideas, consider solutions, plan to solve a problem, or create innovative products that are shared with others.

Grade 4 Specific

RI.4.1. Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.

RI.4.2. Determine the main idea of a text and explain how it is supported by key details: summarize the text.

RI.4.3. Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.

RI.4.7. Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.

W.4.1b. Provide reasons that are supported by facts and details.

W.4.7. Conduct short research projects that build knowledge through investigation of different aspects of a topic.

W.4.8. Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

SL.4.2. Paraphrase portions of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.

4.EL.A.1. With teacher guidance, develop learning goals, select tools to achieve them, and reflect on and revise the learning process as needed to achieve goals.

4.ID.A.1. Demonstrate how a design process works to generate ideas, consider solutions, plan to solve a problem, or create innovative products that are shared with others.

Grade 5 Specific

5-ESS3-1 (Earth and Human Activity). Obtain and combine information about ways individual communities use science ideas to protect the Earth’s resources and environment.

RI.5.1. Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.

RI.5.2. Determine two or more main ideas of a text and explain how they are supported by key details; summarize the text.

RI.5.3. Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text.

RI.5.7. Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.

W.5.1b. Provide logically ordered reasons that are supported by facts and details.

W.5.7. Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

W.5.8. Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.

SL.5.2. Summarize a written text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.

5.EL.A.1. Develop learning goals, select the technology tools to achieve them, and reflect on and revise the learning process as needed to achieve goals.

5.CC.A.1. Recognize and utilize appropriate media and formats for specific audiences.

Investigation Guide - Engineering Design Process: Solutions for Space Travel

	Time	Summary	Focus Question	Writing	Assessment
Activity 1: Research 3D Printing and Space Applications	Explore section: 1 hour Explain section: 1 hour Apply section (optional): 3 hours	Students will collect and organize information gathered from a variety of resources and media about 3D printers and their application to space travel and exploration.	How are 3D printed materials being utilized in space?	Activities include: ● Developing opinion statements ● Writing descriptive paragraphs ● Drawing conclusions ● Creating a multimedia presentation (optional)	● Student Paragraph Checklist ● Paragraph Scoring Rubric ● Multimedia Rubric
Activity 2: Designing 3D Objects Using Tinkercad	Suggested time: 5 total hours This can be chunked and adjusted based on classroom needs. 1 Day for Tech Trekker to print 3D objects	Students will learn how to design 3D objects by manipulating geometric shapes through a series of modules using Tinkercad.	How can geometric shapes be manipulated to produce a 3D model?	Generate a list of questions about 3D printing that will be revisited throughout the activity.	● 3D Design Scoring Rubric ● Module completion checklist
Activity 3: Designing Solutions using the EDP to Space Problems	Suggested Time: 4-5 hours over various days Intro to Engineering Design Process: 1 hour Space Needs & Research: 1 hour Engineering in Tinkercad: 1-2 hours 1 Day for Tech Trekker to print 1st round of 3D objects Review printed objects & redesign to improve: 1 hour 1 Day for Tech Trekker to reprint 2nd iteration of objects	Students will use the knowledge gained in the first two activities to explore deeper into what 3D objects could be useful in space. Students will apply knowledge by identifying a problem in space and working through the Engineering Design Process to create a solution to the identified problem, then print it out using the 3D printer.	How do engineers use the Engineering Design Process to design solutions to problems?	Students will use complete sentences to complete the Engineering Design Rubric. Additional option: Students can write a report to describe how they used the Engineering Design Process to create their projects and how they will address their identified problems.	● EDP worksheet ● Rubric for Project Design

Activity 1: Research 3D Printing and Space Applications

Activity 1: Research 3D Printing and Space Applications	**NGSS / NVACSS:** 5-ESS3-1 (Earth and Human Activity). Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment. RI.3.1. Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. RI.3.2. Determine the main idea of a text, recount the key details and explain how they support the main idea. RI.3.3. Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. RI.3.7. Use information gained from illustrations (e.g., maps, photographs) and the words in a text to demonstrate understanding of the text (e.g., where, when, why, and how key events occur). W.3.1b. Provide reasons that support the opinion. W.3.7. Conduct short research projects that build knowledge about a topic. W.3.8. Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. SL.3.2. Determine the main ideas and supporting details of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally. RI.4.1. Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. RI.4.2. Determine the main idea of a text and explain how it is supported by key details: summarize the text. RI.4.3. Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text. RI.4.7. Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.

	W.4.1b. Provide reasons that are supported by facts and details. W.4.7. Conduct short research projects that build knowledge through investigation of different aspects of a topic. W.4.8. Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. SL.4.2. Paraphrase portions of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally. RI.5.1. Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. RI.5.2. Determine two or more main ideas of a text and explain how they are supported by key details; summarize the text. RI.5.3. Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text. RI.5.7. Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. W.5.1b. Provide logically ordered reasons that are supported by facts and details. W.5.7. Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. W.5.8. Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. SL.5.2. Summarize a written text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.
Objectives	**Reasoning Targets:** 1. Students understand the benefits and disadvantages associated with 3D printing in everyday life, while considering space applications. 2. Students understand the contributions of 3D printing on space travel and exploration. 3. Students understand the time and cost-saving benefits of having 3D printing available in space. 4. Students understand that sustainability is equally as important in space as here on Earth.

	Performance Targets: 1. Students can develop essential questions on a specific topic (3D printers). 2. Students can decipher information from an array of diverse media. 3. Students can identify and compare the benefits and disadvantages associated with 3D printers/printing. 4. Students can draw conclusions regarding the impact of 3D printing in space. 5. Students can connect sustainability practices applied in space with saving time and decreasing costs.
Vocabulary	3D printer 3D printing additive manufacturing advantage/disadvantage benefit NASA sustainability
Materials	● Teacher computer with overhead displaying capabilities ● Chromebooks or other technology - if unavailable, teachers can lead students through activity with overhead while students record ideas, thoughts, opinions, etc. on note paper or in their science journal. ● Paper (note paper/journals and blank printer paper) ● Pencils ● Colored pencils, markers, and/or crayons for foldable activity
Focus Questions	How are 3D printed materials being utilized in space?
Procedures	**Please Note:** This introductory segment can be completed in as little as a few days and delivered in a variety of methods. If students are already familiar with 3D printers, you may opt to skip a section or two of the research tasks embedded in the 3D Printers and Space HyperDoc (see below). Students with limited knowledge of 3D printers might be encouraged (or guided) to complete the **Explore** and **Explain** sections of the research activity. Students can simply record responses, paragraphs, thoughts, ideas, etc. in a science journal instead of completing these activities on a Chromebook or other device. Teachers can teach this segment during an ELA block or recruit specialist educators (if available at your school site) to assist with this task. Support staff that might be able to assist with this activity include: Librarians, STEM teachers, Humanities teachers, etc. Teachers can also decide how students will complete this researching activity: ● Whole group instruction with student guidance on how to collect information and then apply it to the task ● Combination of teacher-guided and individual or small group

research
- Partner or individual-directed (possible for 4th grade and likely for 5th grade)

Preparation

1. **Reserve Chromebooks or Computer Lab for at least 5 days.**
2. Review all research materials and check that all links are working.
3. Make copies of Student Paragraph Checklist, Perfect Paragraph Checklist and 3D Research Project Scoring Rubric.

Procedure
(Day 1)

1. Bring the class together for a whole group discussion. State: "Today we will be learning about 3D Printing." Ask the students the following questions and allow enough time for students to share their responses with each other, and as a whole class.
    - Do any of you know what 3D printing is and what you can do with this technology? *(answers will vary)*
    - How might a 3D printer be different from a printer we use in the classroom? (*answers will vary)*

(HOOK)

2. Watch “What is a 3D Printer and How Does it Work?” video:https://youtu.be/Llgko_GpXbI
3. After the video, allow students to discuss their thoughts on the material presented.
4. Explain to students that they will be conducting a research project on 3D printers including history, current uses, and future advancements.
5. Introduce to the students the unit’s focus question: How is 3D printing being utilized in space?
6. Allow the students time to login to their Google Drive & Classroom account to access the digital 3D Printers and Space hyperdoc.
7. Explain to students they will be working through a series of tasks that include viewing various videos, reviewing charts, reading brief articles, and completing specific tasks along the way.
8. Encourage students to complete the **BLUE Explore & Your Task** section.

(DAY 2)

- Bring the class together for a whole group discussion. Ask the students the following questions and allow enough time for students to share their responses with each other, and as a whole class.
    - How is a 3D Printer different from a normal printer? *(A 3D Printer does not use paper. It uses filament made of plastic, rubber, or wood to print 3 dimensional objects. A normal printer uses paper and prints 'flat,' or 2 dimensional images.)*
    - What might be some advantages and disadvantages of 3D printing? *(Possible advantages: flexible design, fast prototyping, strong and lightweight parts, fast design and production, minimize waste, cost effective, environmentally friendly, endless future possibilities, etc.*

Possible disadvantages: limited materials, cost, mass production, loss of (manufacturing) jobs, design inaccuracies, copyright issues, etc.)

- Remind students of the unit's focus question: How is 3D printing being utilized in space?
- Allow the students time to log in to their Google Drive & Classroom account.
- Remind students to start where they left off at the close of Day 1's work.
- Encourage students to complete the **GREEN Explain & Your Task** section.

(DAY 3)

- Bring the class together for a whole group discussion. Ask the students the following questions and allow enough time for students to share their responses with each other, and as a whole class.
    - How are 3D printers saving time and money in space travel and exploration? *(Astronauts on the space station have long been reliant on launches from Earth to bring them spare parts and replacements for things that break. This is not an ideal situation; rocket launches are expensive, and they generate intense vibrations that can shake apart delicate cargo. So having a 3D printer — which builds objects layer by layer out of plastic, metal, or other feedstock materials — on the space station could make crewmembers' lives easier and result in significant savings, NASA officials say. For example, a recent study by the space agency found that about 30 percent of parts aboard the orbiting lab could be manufactured with a 3D printer.* Wall, M. How 3D Printing Could Aid Space Exploration. Space.com. (November 25, 2014).
- Why is sustainability important for space exploration? *(Space missions must be as sustainable as possible because supplies are limited on each spacecraft. The added expenses associated with the weight of launching rockets must be considered too. For human space exploration to be affordable, sustainable, and therefore, successful, every possible advantage to reduce cost must be studied and understood. New ideas for efficiencies must be solicited, explored, and demonstrated to reach realistic and reliable solutions. Deep space exploration is a highly complex endeavor involving complex trade-offs in cost and risk.* Cooke, D. Op-ed - Reuse and Sustainability in Deep Space Exploration. *SpaceNews*. (October 29, 2018).

Optional

- Explain to students that the culminating project is to develop a multimedia visual aid supporting the idea that 3D printers are necessary in space and that all space scientists need training and experience with 3D printing. The multimedia visual aid can be completed in a variety of formats - students can choose which format works best for their project.
- Provide a timeline to students for completing the multimedia visual aid (suggested time: at least 3 hours; 1 hour for the next 3 days).
- Remind students of the unit's focus question: How is 3D printing being utilized in space?

- Allow the students time to log in to their Google Drive & Classroom account.
- Remind students to start where they left off at the close of Day 2's work and that Day 1 and Day 2 work must be completed before moving onto the last task (**ORANGE Apply & Your Task**).

(DAY 4) Optional

- Bring the class together for a whole group discussion. Ask students what challenges or difficulties they are experiencing with the development of their multimedia visual aid.
    - Allow students to problem solve and assist each other first before providing ideas and suggestions for support.
- Remind students of the unit's focus question: How is 3D printing being utilized in space?
- Allow the students time to log in to their Google Drive & Classroom account.
- Provide a timeline reminder to students (this is day 2 of this 3-day project).

(DAY 5) Optional

- Bring the class together for a whole group discussion. Ask students what challenges or difficulties they are experiencing with the development of their multimedia visual aid.
    - Allow students to problem solve and assist each other first before providing ideas and suggestions for support.
- Remind students of the unit's focus question: How is 3D printing being utilized in space?
- Allow the students time to log in to their Google Drive & Classroom account.
- Encourage students to complete their multimedia visual aid (this is day 3 of this 3-day project).

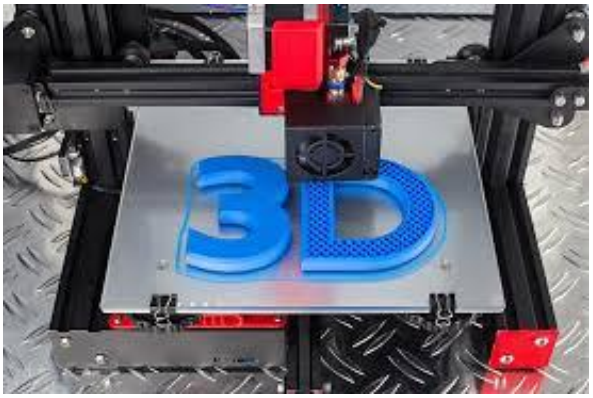
9. **Helpful Tips for Teachers**
    - Students unfamiliar with the Google platform may require extra assistance, but instruction can be shown to all students via teacher's overhead demonstration.
    - Daily whole group questions and discussions aid ELL and other struggling students.
    - Multimedia visual aid can be in a variety of forms (Google Drawings, Prezi, Infographic, Google Slides, Powtoon, Easelly, Glogster, VoiceThread, Flip Charts, Posters, Videos, Skits with Artifacts/Props, etc.; allow student choice, which increases student interest. (McGuire, S. 10 Types of Visual Aids For Learning [+ Teaching Aid Templates]. (September, 28, 2018).

Optional Extension

- Allow additional time for students to view classmates' multimedia visual aids (located in Google Classroom).
- Students give presentations using their multimedia visual aids, and invite

	parents to view them. **Modifications/Suggestions** ● Estimated time for this lesson is 5 hours. This can be broken-up and adjusted based on your classroom needs. ● **Students can work in groups of 2 if there is limited access to technology.** ● Ask students who are ahead and really interested in 3D printer research and creating multimedia visual aids to act as experts and help those who need extra assistance. Once a student has assisted someone else, it is that new student's job to help the next student who needs help. This will give everyone the opportunity to be a leader and act as a student expert.
Assessment	● Students will use teacher-provided Student Paragraph Checklist (self-access) ● Perfect Paragraph Rubric ● 3D Research Project Scoring Rubric
Other Helpful and Interesting Resources	3D Printing and Space Exploration: How NASA Will Use Additive Manufacturing (January 17, 2020). NASA Funds Demo of 3D-Printed Spacecraft Parts Made, Assembled in Orbit (July 12, 2019). NASA Turns to 3D Printing to Help Astronauts Aboard the International Space Station (includes a short article and an excellent 6 minute video of using printers in space) (October 24, 2018). Solving the Challenges of Long Duration Space Flight with 3D Printing (December 16, 2019).

3D Printers and space

Explore	Your Task
What is a 3D Printer? How does it work? Watch this VIDEO.  What are five questions you have about 3D printing (in red)? 1. 2. 3. 4. 5. Review this CHART about how 3D printing works, then describe the four steps in your own words (in red).	You were recently hired by NASA and have been tasked with researching the use of 3D printers in space. In order to learn more about the benefits (advantages) and disadvantages of 3D printing, you must conduct more research. Watch this VIDEO and answer the following question: In your opinion, what is the greatest advantage (in red) and disadvantage (in green) of 3D printing? Advantage: Disadvantage: After watching this VIDEO and reading this ARTICLE from NASA, explain (in red) how 3D printing is improving space travel and exploration? Remember to cite specific details and examples.
Explain	**Your Task**
Now that you have gained some important background knowledge about 3D printers, it is time to explore the benefits associated with using 3D printers in space. First, watch this VIDEO. Next, learn more about cost-saving benefits	Your task is to create a 4-tab foldable that will be used to document your learning and understanding about 3D printers using the videos and links provided as well as outside resources. HERE is how to make your 4-tab foldable. The four labels for your foldable are: 1. History

and sustainability HERE.

Explain how having 3D printers in space can save time and money while also being sustainable (in red):

2. Current Uses
3. Future Advancements
4. Interesting Facts

→ Remember to leave an edge (as seen on the video) for your project title "3D Printer" and your name.
→ Include a picture and notes for each label.

Apply

Since you now have a solid background on 3D printers, it is time to prove to your supervisor that you are ready to go out into the field and advocate for 3D printing training for all astronauts and other space scientists.

Your challenge is to create a multimedia visual aid supporting the idea that 3D printers are necessary in space and that all space scientists need training and experience with 3D printing.

Goldstein, P. FedTech. (2018, October 24). NASA Turns to 3D Printing to Help Astronauts Aboard the International Space Station. Retrieved June 20, 2020, from https://fedtechmagazine.com/article/2018/10/nasa-turns-3d-printing-help-astronauts-aboard-international-space-station#:~:text=NASA helps astronauts print out handy tools in a speedy fashion.

Your Task

Your multimedia visual aid must include the following information:

- Background Information (History of 3D printing in space)
- Benefits of printing in space:
  - Time-saving
  - Cost-saving
  - Sustainability
  - Any other ideas?
- Importance (purpose) of training all space scientists with 3D printing
- Recommended 3D printing training for space scientists

You can use any of the following resources to create a presentation for your supervisor.

Google Drawing
Prezi
Infographic
Google Slides
Powtoon
Easelly
Glogster
VoiceThread
3D Poster (technology not needed)
Tri-fold Pamphlet (technology not needed)

Copy and paste a link to your completed presentation here (in red):

Turn in this assignment to Google Classroom so it can be shared with others!

(Link to 3D Printers and Space HyperDoc)
https://docs.google.com/document/d/1rOmm4Izc2by-obnhQdZJw090KK0G0aj4PDF7Uu6RUoE/edit?usp=sharing

Student Paragraph Checklist

Name: _____

Assignment/Date: _____

_____

- ☐ Topic Sentence
- ☐ Detail Sentence #1
- ☐ Detail Sentence #2
- ☐ Detail Sentence #3
- ☐ Concluding Sentence
- ☐ Capital letters to start
- ☐ Punctuation to end

Adapted from C. Wegley. Paragraph Rubric. (August 7, 2016).

(Link to Student Paragraph Checklist times 4 per sheet access
https://drive.google.com/file/d/1TuapiqdcLdGfjhQxxEaMS8t5mxQnkWOw/view?usp=sharing

The Perfect Paragraph Rubric

	Level 1	Level 2	Level 3	Level 4
Topic Sentence (Introduction)	Weak introductory sentence	Introductory sentence evident, basic format	Introductory appropriate and shows some creativity	Introductory sentence is appropriate, imaginative, and captures attention.
Understanding of structure, use of transition words	Shows little understanding of sequence Very few linking words	Shows some understanding of sequence Few linking words, not always used correctly	Shows a clear understanding of sequence Good use of linking words, appropriate to the structure	Shows a clear understanding of paragraph structure with a creative slant Excellent use of correct linking words
Supporting Details	Supporting details are limited, weak or unrelated	Supporting details relate to topic but undeveloped	Supporting details are well developed and show good understanding of topic	Supporting details are well-developed, effective, and creative.
Conclusion	Weak concluding sentence	Concluding sentence evident, basic format	Good concluding sentence	Concluding sentence is strong, imaginative and ties things together well

Adapted from K. Hortons. Perfect Paragraph Rubric. Teacher Pay Teachers Free Resource. (August 7, 2017).

(Link to Perfect Paragraph Rubric access) https://drive.google.com/file/d/1ZP5XRsceCF7X-wuvYQVoMmNwAYMf8GyE/view?usp=sharing

3D Research Project Scoring Rubric

Title - colorful, creative, and clearly states the topic of research

Exceeds (5) Meets (4) Approaches (3)

Section Headers - each section header is large, colorful, and stands out

Exceeds (5) Meets (4) Approaches (3)

Image(s) - pictures, diagrams, or other visual images are included

Exceeds (5) Meets (4) Approaches (3)

Information - all information is complete, detailed, & paraphrased/written in own words

History of 3D Printing

Exceeds (5) Meets (4) Approaches (3)

Benefits

Exceeds (5) Meets (4) Approaches (3)

Purpose of Training

Exceeds (5) Meets (4) Approaches (3)

Training Recommendations

Exceeds (5) Meets (4) Approaches (3)

Total Points: _____

Activity 2: Designing 3D Objects Using Tinkercad

Activity 2: Designing 3D Objects Using Tinkercad	**NGSS / NVACSS:** 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. SEP-1. Asking Questions and Defining Problems SEP-5. Using Mathematics and Computational Thinking SEP-6. Constructing Explanations and Designing Solutions SEP-8. Obtaining, Evaluating, and Communicating Information CCC-2. Cause and Effect: Mechanism and Explanation CCC-3. Scale, Proportion, and Quantity CCC-6. Structure and Function
Objectives	**Reasoning Targets:** 1. Students understand the basic concept of how 3D printers work. 2. Students understand the principles of designing models for 3D printing. 3. Students understand the basic features of design software, and how it can be easily used for their needs. **Performance Targets:** 1. Students can execute the steps of multi-step tutorials. 2. Students can develop a graphical representation of a 3D object using design software. 3. Students can compare and evaluate whether or not their design matches the model provided. 4. Students can safely print an object using a 3D printer.
Vocabulary	filament align scaling group ungroup workplane plane rotate flip dimensions extrude retract export handle

	.obj
Materials	● 3D Printer ● Filament ● Chromebook or Other Technology ● Checklist Handout ● 3D Printed Demonstration Models ● Scoring Rubrics
Focus Questions	How can geometric shapes be manipulated to produce a 3D model?
Procedures	**Preparation** 1. **Contact Tech Trekker prior to beginning this unit so they can ***mail you*** 3D Printed Demonstration Models.** These models will be used to introduce this activity to students. However, if you have access to a 3D printer, you can print several objects yourself from Tinkercad. 2. Create a FREE Tinkercad account for yourself (www.tinkercad.com). 3. Setup your classroom and add your students. a. Click on the "Teach" tab. b. Choose "Add your students through Tinkercad Classrooms" under Manage your classroom in Tinkercad. c. You can then create a new class and input your students by either copying/pasting your class list or inputting them individually. d. Generate a class code to share with your students. e. Students will log into their accounts using their personalized usernames and invitation codes. A tutorial is available at https://blog.tinkercad.com/2019/08/05/introducing-tinkercad-classroom 4. Take time to become familiar with Tinkercad by completing the first five modules listed on the checklist. This will give you the opportunity to learn the mechanics and tools needed to design and build 3D images. 5. Make enough copies of the checklist for each student in your classroom. **Procedure** 1. Show students the 3D printer and have them pass around the 3D objects you previously printed. As they do this, explain that they will learn how to design their own 3D-printed objects! 2. Ask students to write down questions they have about designing and printing 3D objects in teams. 3. Provide time for groups to share and answer each other's questions. 4. Create a class list of questions that cannot be answered. Post this in the room and come back to it regularly to see if students can answer any of the questions. 5. As a class, explore the Tinkercad website and review the "Designing 3D Objects Using Tinkercad Checklist." Explain that they will be working through a series of modules to learn how to create their own 3D images by manipulating geometric shapes. This is a self-paced program so students can work through the modules as fast or slow as needed.

6. The modules include:
    - Introduction to 3D Primitive Shapes
    - Navigation and Menus
    - Testing Your New Navigation Skills
    - Moving, Rotating, and Scaling Objects
    - Basic Button
    - Your Choice Button: Flower Button, Bat Button, Skull Button, or Teddy Bear Button
    - Create Your Own Luggage Tag
    - Minecraft Party Glasses
    - Die from Scratch
    - Making and Manipulating Grouped Objects
    - Use the Align Tool and Workplace Helper
    - YOUR CHOICE. . .. choose any lesson or project on Tinkercad to complete.
7. Review safety information and behavior expectations ***(this is an important step).***
8. Have students log into their accounts using their personalized usernames and invitation codes and begin.
9. Choose which item(s) you will allow students to 3D print. Buttons are the fastest to print. This would be the ideal object to print for large classes. Allow each student to print at least one object to take home.
10. Check student progress, mark completed modules, and provide guidance as needed.
    - **Questioning Ideas While Students Are Designing:**
        - What shapes did you manipulate to create this 3D object? How did you change them? *(answers will vary)*
        - How do you identify the dimensions of the object? What do the numbers represent? *(Select the object and click on one of the corner handles. The dimensions of the shape will appear in millimeters.)*
        - If you wanted to change the scale of the object, how would you do this? *(Select the object and click on one of the corner handles. Drag the handles inward or outward to make the object larger or smaller.)*
        - Why would you need to use different workplanes when creating a die? How is this helpful? *(Tinkercad's Workplane Helper creates a new home for objects based on the surface of another object. By adding new workplanes, you will be able to make changes to each side of the die one at a time.)*
        - Why is grouping helpful? What does it do? *(Grouping together a set of shapes will merge the objects together. For example, if one shape is solid and the other is a hole, then the hole will appear in the solid object.)*
    - **Sharing/Closure Suggestions:**
        - What challenges did you face today? How did you overcome these obstacles?
        - What is something new you learned today about 3D printing?
        - Are you happy with what you accomplished today? Why or why not?

        - What is your goal tomorrow? How will you achieve this goal?
    11. Students will work through these tasks at different rates, so it is important to have options for students who finish early. Early finishers can….
        - choose additional space-themed projects or lessons to complete;
        - visit the empty work plane to create their own 3D printed objects related to space and space travel.

Contact Tech Trekker to schedule a day for them to come to your school and print all of your students' creations.

12. **Helpful Tips**
    - Save all student work to one flash drive. Name each file with student's name and the type of object (i.e., Simon - Button).
        - Export each image as a .obj from Tinkercad
        - Import the file into the Zortrax software
    - Place each printed piece in a sealable storage bag and label with the student's name.
    - These tips will be especially helpful if Tech Trekker is unable to print all of the items in one day and must finish them at a later time.

Extensions

- Create a gallery for students to share their 3D-printed objects, and invite other classes and parents to view them.
- Create a time-lapse video of 3D objects being printed.
- Combine 3D printing and coding using Tinkercad's Codeblocks (https://www.tinkercad.com/learn/codeblocks).

Modifications/Suggestions

- The estimated time for this lesson is 8 hours. This can be broken-up and adjusted based on your classroom needs.
- Students can work in groups of 2 if there is limited access to technology.
- Ask students who are ahead and really interested in 3D printing to act as experts and help those who need extra assistance. Once a student has assisted someone else, it is that new student's job to help the next student who needs help. This will give everyone the opportunity to be a leader and act as a student expert.

Safety Information

Adult supervision is necessary to prevent student injuries or damage to the 3D printer. When the printer is in use, please take the following precautions:

- The Zortrax is an enclosed printer, so children will not be able to touch the extruder. The extruder becomes extremely hot, reaching temperatures over 200 degrees.
- For safety reasons, students should not take printed objects out of the 3D printer.
- Rafting and other structural filament may need to be removed from printed

	objects. The tools used to remove these are sharp and should only be used by an adult.
Assessment	● A scoring rubric will be used to assess the functionality, critical thinking, creativity, and aesthetics of the printed objects created by each student. ● Students will use a rubric to self-assess their own work. ● Students will turn in their “Designing 3D Objects Using Tinkercad” checklists.

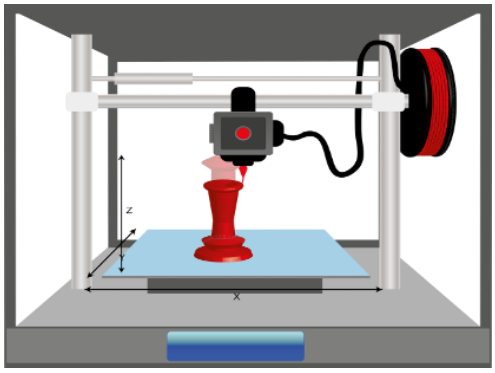
Designing 3D Objects Using Tinkercad

<u>Directions</u>: After you have completed each module, your teacher must observe your results and mark that it has been completed before you can move forward.

<u>Click on "Learn" then "Projects" then "Introduction to 3D Primitive Shapes"</u>

_____ 1. Introduction to 3D Primitive Shapes

<u>Click on "Learn" then "Projects" then "Let's Learn Tinkercad"</u>



_____ 2. Navigation and Menus

_____ 3. Testing Your New Navigation Skills

_____ 4. Moving, Rotating, and Scaling Objects

<u>Click on "Learn" then "Lessons" then "See All Lessons"</u>

_____ 5. Basic Button

_____ 6. Your Choice Button: Flower Button *(easy),* Bat Button *(easy),* Skull Button *(hard),* Teddy Bear Button *(hard)*

_____ 7. Create Your Own Luggage Tag

_____ 8. Minecraft Party Glasses

_____ 9. Die from Scratch

<u>Click on "Learn" then "Projects" then "Let's Learn Tinkercad"</u>

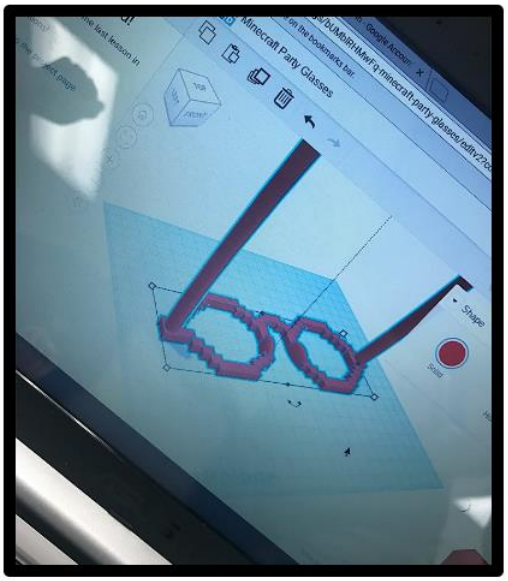
_____ 10. Making and Manipulating Grouped Objects

_____ 11. Use the Align Tool and Workplace Helper

<u>YOUR CHOICE! ! ! !</u>

_____ 12. Your Choice... choose any lesson or project on Tinkercad to complete

3D Printed Student Examples



3D Challenge Student Self-Assessment

	Exceeds	Meets	Approaches
Functionality	Design is printed to the correct scale. Solved all aspects of the problem/design challenge. Performs the function it was designed to do.	Design is printed to the correct scale. Solved most aspects of the problem/design challenge. One element is incorrect or incomplete. Performs the function it was designed to do.	Scale is off OR is printed a little too large or small. Solved some aspects of the problem/design challenge. Two or more elements are incorrect or incomplete, which prevents the object from functioning properly.
Critical Thinking	Design reflects extensive critical thinking and problem solving. Multiple solutions to problems were created and the best and most appropriate solution was always chosen.	Design reflects critical thinking and problem solving. Suggested solutions to solve problems and chose the most appropriate solution.	Required help to identify problems and brainstorm appropriate solutions. The best solution was not always chosen.
Originality & Creativity	Design is personalized, unique, and shows extensive creativity.	Design is creative and complete. Additional details could have been added to personalize it.	Design is random and creativity is minimal.
Aesthetics	Design is extremely visually appealing and accurate.	Design is visually appealing and accurate. However, the object has some minor design flaws.	Design has many flaws.
COMMENTS/THOUGHTS:			

3D Challenge Scoring Rubric

	Exceeds (5)	Meets (4)	Approaches (3)
Functionality	Design is printed to the correct scale. Solved all aspects of the problem/design challenge. Performs the function it was designed to do.	Design is printed to the correct scale. Solved most aspects of the problem/design challenge. One element is incorrect or incomplete. Performs the function it was designed to do.	Scale is off OR is printed a little too large or small. Solved some aspects of the problem/design challenge. Two or more elements are incorrect or incomplete, which prevents the object from functioning properly.
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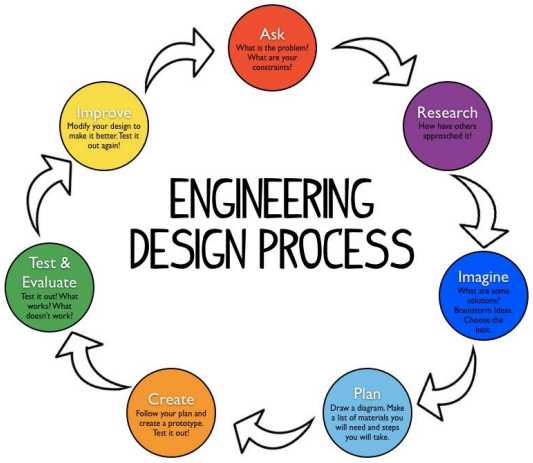
Aesthetics	Design is extremely visually appealing and accurate.	Design is visually appealing and accurate. However, the object has some minor design flaws.	Design has many flaws.
Total Points Earned: _____/20			
COMMENTS:			

Activity 3: Designing Solutions Using the EDP

Activity 3: Designing Solutions Using the EDP	**NGSS / NVACSS:** 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. SEP-6. Constructing Explanations and Designing Solutions SEP-8. Obtaining, Evaluating, and Communicating Information
Objectives	**Reasoning Targets:** 1. Students understand that reflecting on a need or want is an important step in developing solutions to problems. 2. Students understand that solutions to problems are created using the Engineering Design Process. 3. Students understand the steps in the Engineering Design Process. **Performance Targets:** 1. Students can define a problem relating to space travel and define a simple design problem, including specified criteria for success and constraints on materials, time, or cost. 2. Students can generate and compare possible solutions to a problem relating to space travel. 3. Students can plan a design and generate a prototype using 3D printers that provide a solution to the space travel problem identified. 4. Students can evaluate their design solution and come up with an improved iteration of the design.
Vocabulary	engineer assemble disassemble problem solution design brainstorm iteration diagram engineering design process
Materials	Paper & pencils Copy of worksheet Chromebooks or other technology

	3D printer Print of Engineering Design Process (optional)
Focus Questions/ Big Ideas	How do engineers use the Engineering Design Process to design solutions to problems?
Procedures	**Important Note: Before beginning this activity, please plan on requesting the Tech Trekker to return for 2 days (Part 3 & Part 4). The Tech Trekker needs to be requested and scheduled *at least* 2 weeks before the date needed.** **Part 1: The Engineering Design Process** Anticipated Time: Approximately 1 hour NOTE: This lesson could be completed while the Tech Trekker prints out items from Activity 2. 1. Watch "What is Engineering?" video to introduce engineering: www.youtube.com/watch?v=H9VDkvgGmVo 2. Review the steps in the Engineering Design Process: Ask, Research, Imagine, Plan, Create, Test & Evaluate, Improve  3. Ask the students about their understanding of the Engineering Design Process. Teacher will ask: **Why do you think the process is laid out in a circle?** *Answer: The EDP is laid out in a circle because it is an iterative process to help engineers constantly improve their solutions, as needed.* 4. Teacher will ask: **How does using the 3D printer use the Engineering Design Process?** *Answer: 3D printers are used to create solutions to problems or needs. Users imagine, plan, create & test their projects, and then improve on them to make each iteration better.* 5. Review one or more of the following videos to demonstrate how other students have used 3D printers and the Engineering Design Process to find solutions to everyday problems: ○ Design Girls team finds solutions for problems for elderly people in their community: www.youtube.com/watch?v=iJ0Y-Cti9F0 ○ 6th Graders design a clip to help a toddler's leg straps (all students presented a design and they chose top 3 in class to 3D print):

www.youtube.com/watch?v=xlX4HAPEY-s&feature=youtu.be
    - Primary students find solution to problem of mixing up bags (chose best ideas and printed best): www.youtube.com/watch?v=xlX4HAPEY-s&feature=youtu.be
    - Students help solve problems for elderly community members: www.youtube.com/watch?v=9KHCdDuEW-o&feature=youtu.be
    - Students use EDP & 3D printers to solve problems in their school community: www.youtube.com/watch?v=9KHCdDuEW-o&feature=youtu.be
    - Using 3D printers to learn English & design furniture for a doll house: www.youtube.com/watch?v=NcyCppMVFm8&feature=youtu.be
    - Hailey's Hand. See how a 3D printer helps give Hailey a hand. https://www.unlv.edu/engineering/haileyshand
6. Teacher will ask: **How did these students use the Engineering Design Process to come up with solutions to the problems they found?** *Possible answer: The students recognized problems in certain circumstances and designed solutions to those problems. They went through the entire process, including following up with improved iterations after the first printing.*

Breaking Point, if needed

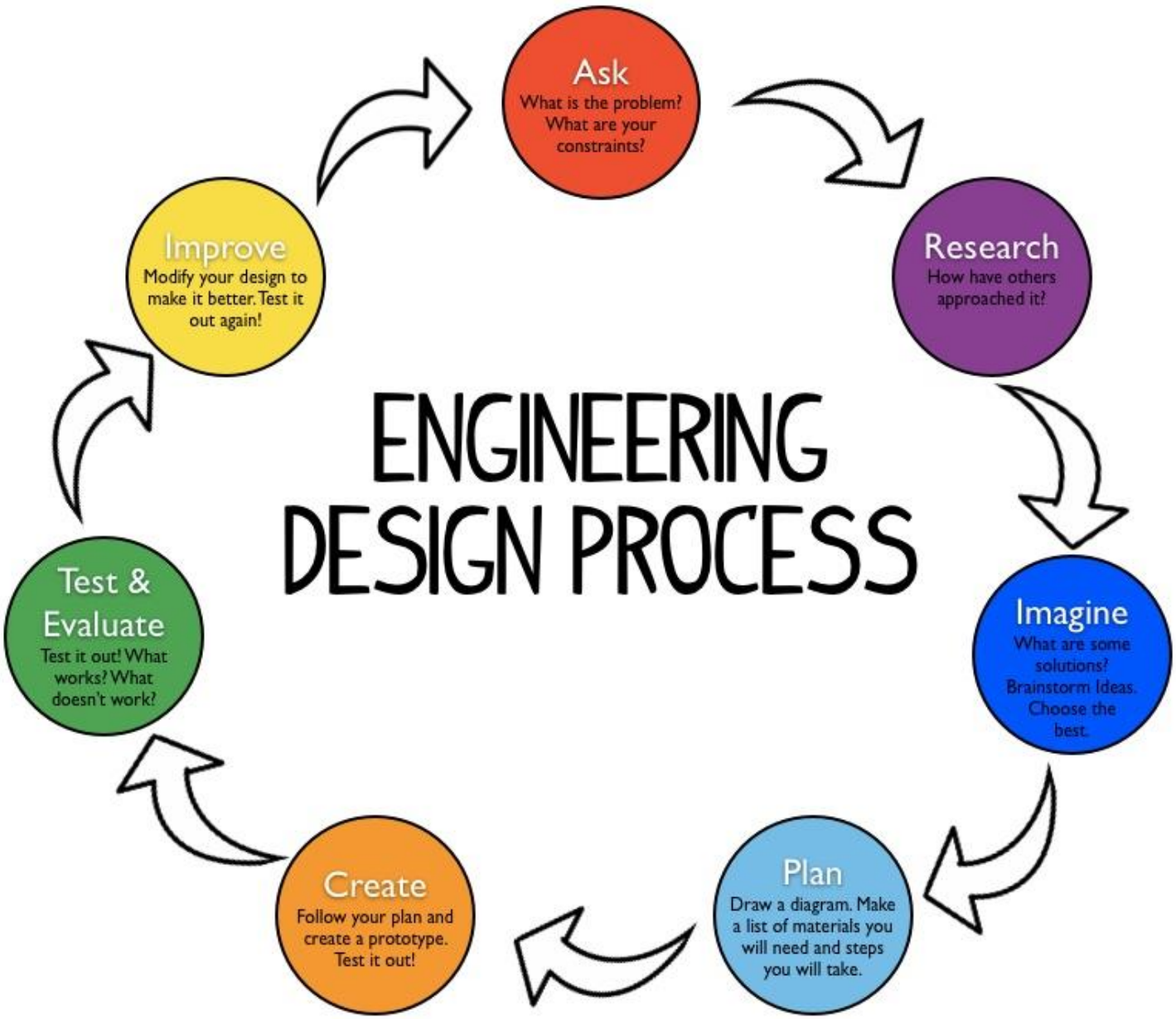
Part 2: Space Travel Problems and Solutions
Anticipated Time: Approximately 1-2 hours

7. Teacher will lead the students in an exploration of possible space travel needs. The following is a list of activities that could be explored in a whole class, small group, or individual student setting.
    - Students can take turns wearing a ski glove and trying to complete a task, such as using a screwdriver to connect an object with screws. This simulates tasks an astronaut might have to complete in space while out on walks (i.e. around the international space station).
    - Imagine living on Mars. What would life be like without a pet? What could you design to help your pet live happily with you on Mars?
    - What would you do for fun if you lived on the Space Station. Design a toy, game, or other device (i.e. something to make reading a book easier) that the astronauts could use to keep themselves entertained.
    - Eating in microgravity is a challenge on the ISS. Even small crumbs or small pieces of salt or pepper can cause damage to the workings of the ISS as they float around. Design something that would make eating on the ISS easier or more enjoyable (www.nasa.gov/audience/formedia/presskits/ffs_gallery_sfn.html - pictures of eating on the ISS).
    - See the following for additional needs that could be explored as identifying problems in space: www.lee.k12.nc.us/cms/lib03/NC01001912/Centricity/Domain/1464/Human%20needs%20in%20space.pdf

8. As a class, decide on one problem that was identified in the above

	activities (EDP “Ask” & “Research”). Each student, or group of students, will use the worksheet to brainstorm solutions for the chosen problem (EDP “Imagine” & “Plan”). After brainstorming, have the students choose one solution to plan by drawing a diagram, listing materials needed, and listing the steps needed to create the solution using the 3D printer. ○ Resource: This explains how NASA is using 3D printed objects on the ISS & in space in general to print objects on the fly, as needed. https://www.nasa.gov/sites/default/files/files/3D_Printing-v3.pdf Video showcasing Zero G 3D printing: https://www.youtube.com/watch?v=1Jwxn6EzW84 9. Schedule Tech Trekker to come. ***Breaking Point, if needed*** **Part 3: Engineer in Tinkercad & Print on 3D printers** Anticipated Time: Approximately 1-2 hours 10. Have students engineer their blueprints in Tinkercad (using skills from Activity 2) (EDP “Create”).* ○ Option 1: Have each student, or group of students, 3D print their blueprints created in Tinkercad. ○ Option 2: Have each student, or group of students, present their ideas to the class. After the presentations, have students decide which 2-3 projects will be printed using the 3D printer. 11. Schedule final visit of Tech Trekker. *This lesson could be completed ***before*** the Tech Trekker comes to save time. ***Breaking Point, if needed*** **Part 4: Review 3D printed options and Improve design** Anticipated Time: Approximately 1-2 hours 12. Have students review the 3D printed objects and evaluate ways to make them better (EDP “Test & Evaluate”). Note: testing will depend on the chosen problem and solution. 13. After reviewing their objects, have students improve their designs and create a new iteration by going through the Engineering Design process again (EDP “Improve”).* 14. Optional writing activity. Students can write a report to describe how they used the Engineering Design Process to create their projects and how they will address their identified problem. *This lesson could be completed ***before*** the Tech Trekker comes to save time.
Assessment	● Students will use teacher-provided rubric to self-assess their own work. ● Rubric Ideas (provide a rubric) *see attached ○ Functionality - solved all aspects of the problem/design challenges; design reflects critical thinking and problem-solving, and performs

	the function it was designed to do ○ Design - printed to the correct scale and no material was wasted ○ Creativity - designs are personalized, unique, and show creativity ○ Aesthetics - final designs are visually appealing and accurate ● Students will turn in their Engineering Design Process worksheets ● Students will turn in Rubric ● Optional: Students will turn in final writing project


ENGINEERING DESIGN PROCESS
Ask
What is the problem? What are your constraints?
Research
How have others approached it?
Imagine
What are some solutions? Brainstorm Ideas. Choose the best.
Plan
Draw a diagram. Make a list of materials you will need and steps you will take.
Create
Follow your plan and create a prototype. Test it out!
Test & Evaluate
Test it out! What works? What doesn't work?
Improve
Modify your design to make it better. Test it out again!

Name(s): _____

The Engineering Design Process (Ask-Plan)

Ask & Research **(What's the problem?)**	**Brainstorm** **(What are some possible solutions?)**
Plan	
Draw a Diagram	
List of Materials	**Steps to Take**

Engineering Design Cycle
Final Product Scoring Rubric

	Exceeds (5)	Meets (4)	Approaches (3)
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