Manufacture Your FUTURE

ARCONIC FOUNDATION

Discovery EDUCATION

Virtual Field Trip Educator Guide

All GRADE LEVELS

Background

Across industries, 3D printing promises to change manufacturing. Also called "additive manufacturing," the technology has been around since the early 1990s. Early 3D printers were expensive, heavy, and bulky. That has changed in recent years with the availability of affordable desktop 3D printers. The automotive, aerospace, and defense industries were the first to take advantage of 3D printing, which promises stronger, lighter, better performing parts—produced faster and cheaper. For example, product development can be speeded up since prototypes can be quickly and cheaply produced.

> "3D printing has the potential to revolutionize the way we make almost anything."
>
> *—President Barack Obama*
> *2013 State of the Union address*

Major advances in 3D printing applications are underway. New materials, called feedstock, are being used to make products. The early printers used plastic (such as ABS or PVA) as the raw material. Today, feedstock includes metals, carbon fiber, and even biological tissues. The latter has shown potential to support improvements to surgical procedures, organ or joint replacement, and burn treatments.

The principle of 3D printing is straightforward. The operator programs the printer using 3D software. Depending on the desired product, a design may be purchased or may need to be customized for the job. Next, the appropriate feedstock is loaded to the printer. The print head deposits the material according to the program. Layers of material are built up until the desired result is achieved.

It's no exaggeration to say that 3D printing will revolutionize industry as we know it. For students, the prospects are endless. They are at the ground floor of the technology's growth. Students who have backgrounds in design, engineering, software development, materials science, and medicine will be poised to take the most advantage of the opportunities.

References and Further Reading

- What Lies Ahead for 3-D Printing?
- What materials are used in Additive Manufacturing?
- 5 Amazing 3D Printing Careers To Inspire Students
- 10 3D Printing Jobs On the Rise

Pre-VFT Activity

Overview

Students work in small groups to disassemble simple household appliances or handheld home improvement tools (obtained from thrift stores or other inexpensive sources). They itemize the parts found in their devices. Their list should include which parts could be produced by 3D printing instead of traditional casting or assembly. If needed, students research online to identify the specific part and its constituent material(s).

Objectives

Students will be able to:

- Evaluate the feasibility of producing a component using additive manufacturing or 3D printing

Standards

Next Generation Science Standards

- ETS1.B: Developing Possible Solutions: There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)

College and Career Readiness Standards

- CCR Anchor 7: Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation. 7D: Conduct short research projects to answer a question, drawing on several sources and generating additional related, focused questions for further research and investigation. (W.7.7)

Pre-VFT Resources

- **Arconic: The Smart Ink of the Future**
- **Arconic & 3D Printing: Our Revolution is in the Making**
- **Flickr Group: The Art of 3D Print Failure**
- **Objects That Couldn't Be Made Before 3D Printers Existed**
- **What 3-D Printing Can't Do**

Preparation

Before beginning the activity, ask students to bring in an unwanted simple household device or home improvement tool. Simple household appliances such as an electric fan, electric drills, and screwdrivers would work well. If needed, identify the location of a thrift store where an appropriate item could be purchased at low cost.

If a 3D printer is available, print a few simple objects to introduce students to the concept of 3D printing.

Safety Note

Before electrically operated devices are disassembled, be sure to cut the power cord or remove the batteries. If the device has a capacitor (which will only be seen once disassembly is underway), assist students in discharging the capacitor:

1. Remove the capacitor from the circuit.
2. Hold a screwdriver by its plastic handle across the terminals. Be sure to not touch any metal part of the screwdriver.
3. Use a voltmeter to check that the capacitor is fully discharged.
4. Ensure that students wear proper lab attire, including safety glasses. Provide nitrile gloves to keep students' hands clean.

Materials

- Various handheld tools (screwdrivers, scissors, box knife, pliers, etc.)
- Nitrile gloves
- Various small household devices
- Pen
- Paper

Procedure

1. If available, pass around a 3D printed object to introduce the concept of 3D printing.
2. Engage students by asking them to quickly sketch a toy or household appliance they have used.
3. Ask students if they think that their object could be made using a 3D printer.
4. Show students images of 3D printing failures to show that things do not always go as planned, and to emphasize that trial and error are part of the design process.
5. Students work in small groups.
6. Each group chooses (or is given) one of the devices for disassembly.
7. Provide tools needed for disassembly. Be sure to supervise and assist students during this part of the lesson, since they will be using sharp objects.
8. As students take their devices apart, they itemize the parts they find.
9. Encourage groups to be systematic in their lists, including the quantity of each part, the material of which it is made, and its function. (If they're not sure of the material or function, their best guess is fine—the aim is to inspire students to think critically about the materials and their function.)
10. Each group selects one part from their device to evaluate.
11. The groups develop a procedure for evaluation using criteria that they need to determine if the part could be 3D printed.

12 If students struggle with determining evaluation criteria, guide them with specific questions:

- Can the material be used in a 3D printer (e.g., is it plastic or metal)?
- Does the part have a lot of sub-components made of different materials?
- Is the part too complicated to be printed in an additive process?

13 Students present their findings and evaluation process to the class. For example, students could take photos of their selected part and include these in a slide or web page presentation.

During-Virtual Field Trip Activity: To 3D or Not to 3D?

Overview

Students create a T-chart or table to compare 3D printing with traditional manufacturing methods. Students focus on one of the products mentioned during the VFT (e.g., necklace, drone propeller, chocolate bar). They make notes on specific differences (e.g., required machinery, design process, raw materials, manufacturing time, cost, etc.). Students make a note of questions related to their comparisons and tweet their questions to @DiscoveryEd using the #ManufactureYourFuture hashtag.

Objectives

Students will be able to:

- Compare 3D printing with traditional manufacturing
- Distinguish materials that can be 3D printed with those that cannot

Materials

- Student recording sheet
- Online access
- Pen
- Paper

Procedure

1. Students login to the VFT website and into your class Twitter account.
2. Students listen to the VFT interview.
3. As students listen, they make notes about the kinds of materials mentioned by host Darnell and Laurie Markoe.
4. Students record their ideas for new objects that they would like to create using 3D printing.
5. Students categorize their objects by the types of materials needed to create the objects.
6. Students tweet their questions to @DiscoveryEd using the #ManufactureYourFuture hashtag.
7. Students record answers next to the object with its respective material.
8. Students rate the feasibility of producing their object using 3D printing on a scale of 1 to 5, where 1 = not at all feasible and 5 = totally feasible.
9. If time allows, immediately after the VFT, students write down their justification for their rating.
10. Students discuss as a class whether or not future technology will make the production of their object more feasible.

Standards

College and Career Readiness Standards

- CCR Anchor 7: Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words. 7D: Integrate information presented
- in different media or formats (e.g., in charts, graphs, photographs, videos, or maps) as well as in words to develop a coherent understanding of atopic or issue. (RI.6.7)
- CCR Anchor 1: Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence. 1D: Write arguments to support claims with clear reasons and relevant evidence. a. Introduce claim(s), acknowledge alternate or opposing claims, and organize the reasons and evidence logically. b. Support claim(s) with logical reasoning and relevant evidence, using accurate, credible sources and demonstrating an understanding of the topic or text.

Post-VFT Concepts

Post-VFT Concept #1

Overview

Students work in small groups to use 3D printing software to design an object. (Free programs are available online and optional resources are provided.) Depending on students' ability, they can choose an object ranging from a simple geometric shape to more complex objects. Encourage students to create a design that relates to a science- or math-related problem. Students with access to a 3D printer will print their design. Students present their object and explain their design process to the class.

Objectives

Students will be able to:

- Design an object using 3D printing software
- Relate a design to the solution for a science- or math-related problem

Standards

Next Generation Science Standards

- 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.

College and Career Readiness Standards

- CCR Anchor 4: Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience. 4E: Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task. (SL.9-10.4)
- CCR Mathematics Standards
  - Model with mathematics. (MP.4)
  - Use appropriate tools strategically. (MP.5)
  - LEVEL D (+6, 7–8)
    - Draw, construct, and describe geometrical figures and describe the relationships between them.
    - Understand congruence and similarity using physical models, transparencies, or geometry software.
    - Solve real-life and mathematical problems involving angle, measure, area, surface area, and volume: Solve real-world and mathematical problems involving area, volume and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms. (7.G.6)

Post-VFT Resources

Getting started with 3D printing

- **The Top Ten Tips For Getting Started With 3D Printing**
- **3dprintingforbeginners.com**

Free 3D printing software

- **Tinkercad**
- **Thingiverse**
- **24 Best 3D Printing Software Tools of 2018**
- **An Overview Of The Best 3D Printing Software Tools**
- **9 Free 3D Design Programs to Get You Started with 3D Printing**

Preparation

Review the 3D printing resources. If planning to print an object, conduct a few trials with a 3D printer to increase your confidence in guiding students on the process. If classroom computers are used, download the 3D design software ahead of class to save time. Some 3D design programs offer tutorials. These tutorials may be useful background in case students need help creating their designs.

Safety Note

Use of 3D printers involves potential contact with hot materials and sharp objects. If students use the 3D printer, ensure that they wear proper lab attire, including safety glasses. Provide safety gloves to avoid the possibility of cuts and burns.

Materials

- Desktop or laptop computer
- Online access
- 3D printer plus feedstock (optional)

Procedure

1. Students work in small groups.
2. Give each group access to a computer with online access.
3. Students download the 3D printing software if it is not already on their computer.
4. Groups brainstorm an object to design for production by a 3D printer. (Objects could be from the pre-VFT activity or from what they learned during the VFT.)
5. If needed, guide students towards choosing an object that is not too complicated. A simple geometric shape may suffice.
6. To print a 3D object, students follow the instructions from the printer manual.