

Rapid Prototyping Challenge From Blueprint to Physical Prototype

Subject: ADST	Grade: 5–12	Duration: 90–120 min
Lesson Overview	Students apply the Engineering Design Process to solve an authentic engineering challenge through rapid prototyping. Working within design constraints, they begin by creating a simple blueprint, then construct and refine a physical prototype using layered cardboard (and optional clay). Throughout the activity, students test ideas, make design decisions, and iterate on their solutions before transitioning to more advanced prototyping methods.	

Curriculum Ties (in addition to satisfying multiple core competencies):

ADST Core Competencies:

Communication: E.g. Collaborating: Share progress while making sure to increase feedback and collaboration.

Thinking: E.g. Critical and Reflective Thinking: Screen ideas against criteria and constraints first, students will brainstorm and think consciously about their decisions before executing their plan.

Personal & Social: E.g. Social Responsibility: Evaluate the influences of land, natural resources, and culture on the development and use of tools and technologies on the construction of their tower

Content Objectives

Students will:

- Apply the Engineering Design Process to solve an engineering challenge.
- Develop and communicate ideas through engineering sketches.
- Build a rapid physical prototype using simple materials.
- Evaluate and improve their design based on testing and discussion.
- Explain how rapid prototyping supports engineering decision-making.

Materials & Equipment Needed

Consumables: • Cardboard • Clay (optional) • Masking tape • Glue • Hot glue sticks	Non-Consumables: • Hot glue guns • Scissors • Craft knives • Cutting mats • Rulers • Markers
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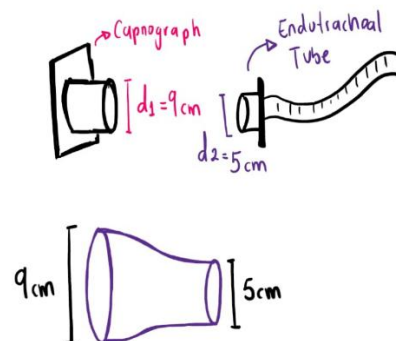
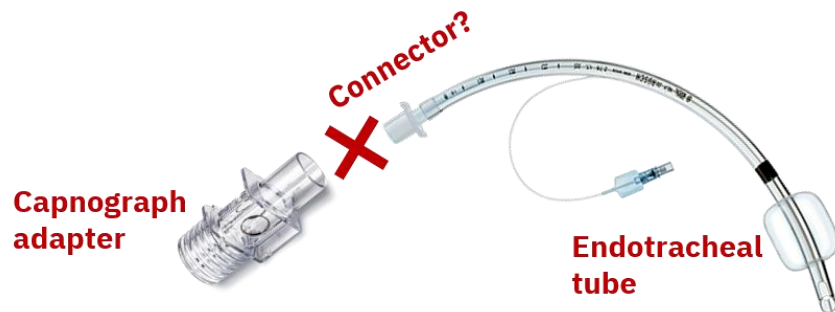
Lesson & Activity

Lesson Stages	Learning Activities
Introduction	• Begin by reviewing how additive manufacturing differs from traditional manufacturing. • Explain that, unlike carving or cutting material away, a 3D printer builds objects one thin layer at a time.

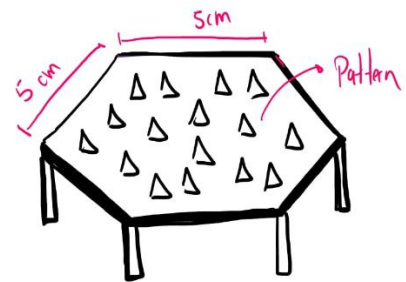
- Show examples of layered cardboard models and discuss how complex objects can be simplified into stacked geometric shapes.
- Introduce the design challenge by explaining that students will act as engineers and prototype an object using the same layered approach used in 3D printing.

Some examples of design challenges include:

- A hospital needs a connector that joins a mechanical ventilator tube to a capnography system. In ICU settings, teams may use equipment from different brands or models, and the capnography adapter does not always fit directly with the endotracheal tube or ventilation circuit. Because commercial connectors can be expensive and frequently replaced, the engineering team is asked to prototype a custom adapter that can fit tubes with different diameters.



- Engineers are using additive manufacturing to create artificial reef structures that support coral growth and ecosystem restoration. These designs often include repeated geometric patterns, textured surfaces, and lightweight structures that help marine organisms attach and grow while remaining stable on the seafloor. Your task is to create a small hexagonal base with repeated geometric patterns on the top surface and short support legs underneath.



Note: This lesson focuses primarily on the importance of prototyping as a way to make ideas visible, test possible solutions, and identify opportunities for improvement. However, it can be expanded to explore the full Engineering Design Process in greater depth. Before beginning the prototype, educators may dedicate additional time to defining the challenge, researching existing solutions and relevant users, identifying criteria and constraints, generating multiple ideas, and selecting a design direction. These stages can be adapted according to the available time, grade level, and complexity of the challenge.

Activity

- Present students with an engineering or design challenge. Encourage open-ended problems that can be solved in multiple ways.
- Before building, students create a quick blueprint showing the overall shape and identifying how the object can be divided into horizontal layers.

- Students then construct their prototype by cutting and stacking cardboard pieces, focusing on function, stability, and efficient use of materials rather than fine details.
- Throughout the activity, encourage students to compare their prototype with their original sketch, discuss design decisions with peers, and make adjustments as needed.

Examples:



- Once the layered structure is complete, students may optionally use 3D pens (<https://the3doodler.com/>) to experience another additive manufacturing technique by depositing material layer by layer, similar to the extrusion process used in 3D printers.



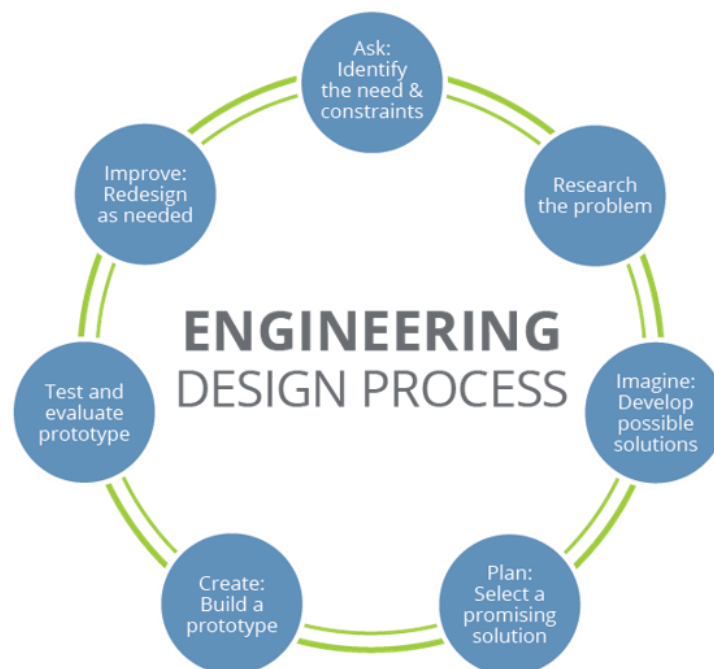
Closure	• Invite students to share their prototypes and explain how they transformed a three-dimensional idea into a series of stacked layers. • Discuss how their designs changed during construction and what modifications they would make in a second iteration. • Conclude by connecting the activity to digital fabrication, explaining that CAD software and slicing programs perform a similar process by converting digital models into hundreds of printable layers before manufacturing begins.
Step Ups & Step Downs	Step Ups • Introduce dimensional constraints, limit the available materials • Students may also recreate their cardboard prototype digitally using CAD software. Step Down • Provide pre-cut geometric pieces, templates for common layer shapes, or partially completed blueprints. • Reduce the complexity of the design challenge by focusing on simple geometric objects before progressing to more functional prototypes.

Background Knowledge

The Engineering Design Cycle:

- Ask
 - What is the problem we're trying to solve?
 - What are the limits that our solution needs to follow?
- Research
 - Has someone already created something like this?
 - Who are the experts in this field?

- Imagine
 - Brainstorm a large quantity and variety of ideas before narrowing the options.
- Plan
 - What criteria should we use to narrow down our ideas?
 - Which ideas need to be screened based on the original constraints we identified?
- Create
 - What kind of prototypes can we create? A sketch, scale model, CAD model, computer simulation, etc
- Test
 - What does our final design need to accomplish? Can we test this with the prototype we made?
 - Run an experiment
 - Create a computer simulation
 - What information are we looking to gain from these tests?
- Improve
 - Based on the results from the testing, what can we improve on our design?
 - Are there certain aspects we found too difficult to create?



Additional Resources

- How 3D printer works: <https://youtu.be/f94CnlQ0eq4>
- Cross-Section: <https://www.youtube.com/watch?v=MeARCoXD03M>