

From Prototype to Product Digital Modeling with CAD and 3D Printing

Subject: ADST	Grade: 5–12	Duration: 90–120 min
Lesson Overview	Students learn how engineers use Computer-Aided Design (CAD) software to create precise digital models that can be manufactured using additive manufacturing technologies. Beginning with a physical prototype or engineering sketch, students recreate their design in Tinkercad using basic geometric solids. They explore how digital models can be modified, measured, and prepared for fabrication before learning how slicing software converts these models into printable layers for a 3D printer.	

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:

- Explain the purpose of CAD in engineering and product design.
- Construct a digital model using basic geometric shapes.
- Modify dimensions and align components accurately.
- Describe how slicing software prepares a model for additive manufacturing.
- Compare physical and digital prototyping methods.

Materials & Equipment Needed

Consumables:	Non-Consumables: • Computers / Laptops • Internet access
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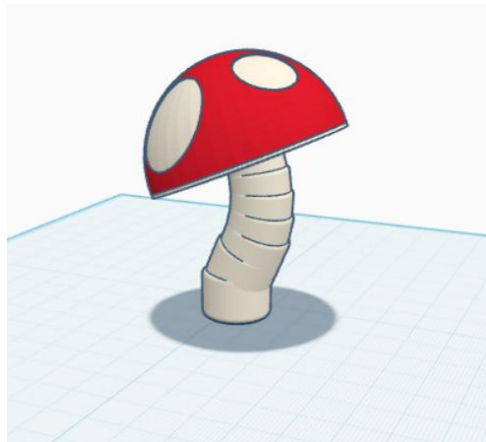
Lesson & Activity

Lesson Stages	Learning Activities
Introduction	• This lesson assumes that students have already completed the early stages of the Engineering Design Process and have identified an engineering challenge, conducted any necessary research, generated ideas, and produced a preliminary sketch or blueprint of their proposed solution. The focus of this lesson is the digital prototyping stage, where students transform their initial concept into a precise three-dimensional CAD model. • Begin by discussing the role of Computer-Aided Design (CAD) in engineering and product development. • Explain that engineers use CAD software to communicate ideas, test dimensions, modify designs efficiently, and prepare products for manufacturing. Unlike hand sketches, CAD models allow designs to be measured accurately, refined quickly, and shared with others throughout the design process. • Introduce Tinkercad (https://www.tinkercad.com/) as an accessible CAD platform and explain that students will recreate their sketch digitally using simple geometric shapes. ○ Emphasize that this step represents another form of prototyping—one that enables engineers to evaluate and improve designs before moving to manufacturing technologies such as 3D printing. ○ Tinkercad tutorial: https://youtu.be/QIn9c5TjrKk

Activity

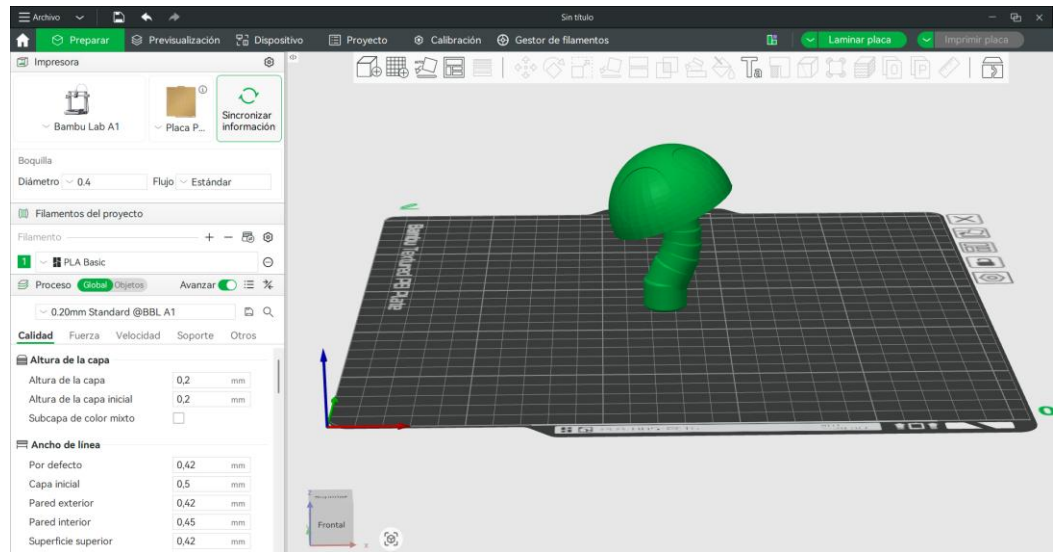
- Students begin by reviewing their engineering sketch or physical prototype and identifying the key features that will need to be recreated digitally.
 - Encourage them to break complex designs into simple geometric components before opening Tinkercad.
- Introduce the basic tools available in Tinkercad, including creating and resizing geometric solids, aligning objects, grouping shapes, duplicating components, and creating holes.
- Demonstrate each tool briefly while students follow along with a simple example.
- Students then recreate their own design using these tools, focusing on proportions, dimensions, and functionality rather than small decorative details. Throughout the activity, encourage students to continuously compare their CAD model with their original sketch or prototype, making modifications as new ideas emerge.

Example:



- Once the digital model is complete, demonstrate how to export the design as an STL file and explain how slicing software converts the model into hundreds of thin horizontal layers that can be interpreted by a 3D printer. If available, prepare one or more student models for printing and discuss how settings such

as layer height, infill, supports, and print orientation influence the final product.



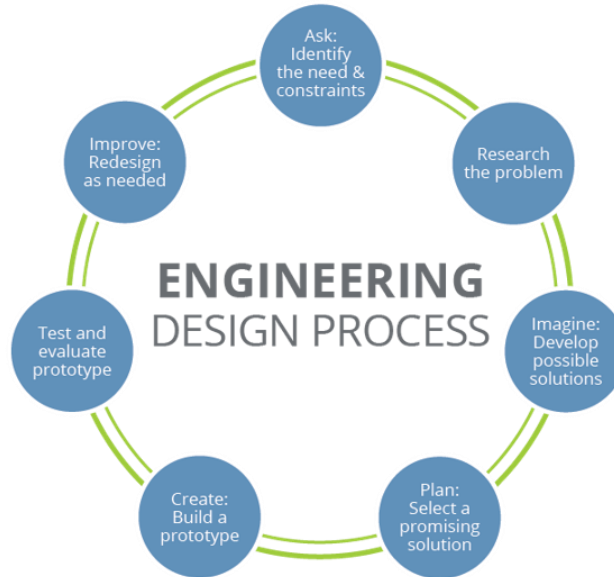
Closure

- Invite students to compare their physical and digital prototypes, discussing the advantages and limitations of each approach.
- Ask students how their design changed during the modeling process and what improvements they would make before manufacturing.
- Conclude by reinforcing that CAD models are more than digital drawings—they are engineering tools that allow designers to communicate ideas precisely, test dimensions, revise solutions efficiently, and prepare products for manufacturing.
- Emphasize that digital prototyping is an iterative process, and that engineers frequently move back and forth between sketches, physical prototypes, CAD models, and manufactured products before arriving at a final solution.

Step Ups & Step Downs	Step Ups • Introduce dimensional constraints or tolerances that require precise measurements. • Have students redesign an existing prototype to improve its function or reduce material usage. • Print selected student models and evaluate how well the manufactured object matches the original design. • Extend the activity by introducing slicing software, allowing students to adjust print settings such as layer height, infill density, supports, and print orientation, and predict how these parameters affect print quality, strength, print time, and material consumption. Step Down • Provide a guided Tinkercad tutorial before students begin their own designs. • Supply partially completed CAD files that students can modify rather than creating a model from scratch. • Limit the activity to combining a small number of basic geometric solids. • Ask students to recreate a simple everyday object before progressing to a more complex engineering design. • Pair students so they can collaboratively solve modeling challenges and support one another throughout the design process.
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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>
- Thinkercad tutotrial: <https://youtu.be/QIn9c5TjrKk>
- CAD: https://youtu.be/EPwOgh-M_ok