PROCESS

Module V: Lesson Plan

MODULE GOALS

In arts and craft traditions, process is at least as important as the final creative product. Some art practices, like the mandala, place all of the importance in the process of making, destroying the product as soon as it is finished. But even traditions like manufacturing, where the product is the focus, demand careful attention to the creative process in order to create a high-quality artistic product.

Designing and digitally creating a 3-D form via online platforms like TinkerCAD is the first step in additive manufacturing. In order to correctly prep your form and make sure the design is readable to 3-D printers, print settings, file formatting, and other aspects of the printing process must be taken into account. In this module, students will gain a greater understanding of how to successfully prepare and set up their design for printing. By better understanding the process of designing and producing a successful 3-D print, students will develop a greater agency over that process, enabling them to experiment with, or fine-tune to process with artistic intent.

ESSENTIAL QUESTIONS

- What process(es) does a digital design need to go through in order to be 3-D printed?
- What types of files can a 3-D printer read?
- What do the different file types (**.STL, .OBJ**) mean?
- How does **infill** affect a 3-D print?
- How does layer thickness affect a 3-D print?
- How does the orientation of a digital design affect the way it is printed?
- How do artists manipulate the 3-D printing process(es) to artistic ends?

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MEANING AND ACQUISITION

- Students will know what file type **.STL** means and how it is created and interpreted by the 3-D printer.
- Students will be able to prepare their own designs for print.
- Through the process of prepping their own designs for printing, students will understand how print settings affect an object's print time.
- Through the process of prepping their own designs for printing, students will understand how print settings affect post-processing efforts.
- Through the process of prepping their own designs for printing, students will understand how print settings affect print orientation and support material for printing.
- Through the process of prepping their own designs for printing, students will understand how print settings affect an object's surface quality.
- Students will be able to choose the most appropriate print settings for their object, including layer thickness, infill density, and orientation on the plate.

FORMATIVE ASSESSMENT STANDARDS

- Students demonstrate willingness to experiment and develop skills in new art-making technologies **(Cr2.l.5a)**.
- Students know and use fundamental vocabulary relevant to the processes involved in the preparation of digital files for printing **(Cr3.1.1a)**.
- Students show willingness to revise and modify their existing models in relation to the information obtained through the digital file preparation process **(Cr.1.1.lla)**.
- Students are able to discuss and explain the printing preparation process to their peers and help facilitate peer-to-peer learning **(Crl.1.11)**.

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SUMMATIVE ASSESSMENT STANDARDS

- Student work exemplifies an effective use of equipment and digital tools into the preparation of 3-D designs for their printing **(Cr2.1.IIa)**.
- Student work exemplifies a synthesis between creative and analytical principles and techniques of the visual arts and technical concepts from the sciences **(Cr2.3.IIa)**.
- Student work demonstrates the exploration of new art-making technologies and the approaches associated with these **(Cr2.I.4a)**.

MATERIALS

- Laptop with slicing software (this tutorial will use Cura, but other options, such as Slic3r, will work well, too).
- A mouse.
- Example objects:
  - Objects printed with different STL resolutions.
  - Objects printed with supports, at different orientations.
  - Successful and unsuccessful prints.
  - Examples using different materials (e.g. metal, flexible material, multi-material, wood, food).
- One or more 3-D printers.

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KEY TERMS

- **Build plate** - The surface where an object is 3-D printed.
- **Infill** - An internal support structure for printed objects. Making them completely solid would waste a lot of plastic, so infill is usually a grid of supportive plastic inside the model. Infill can be adjusted to be more or less dense, resulting in a sturdier object that uses more material, or a less sturdy object that uses less material.
- **G-code** - A digital file format that represents a 3-D model as a series of stacked layers for a 3-D printer to print.
- **Layer height/thickness** - Height of the horizontally printed layers of a 3-D printed object. The thicker this is, the more visible "ridges" there are on a model. The thinner this is, the more layers the printer needs to print, taking more time.
- **OBJ** - A common digital file format for a 3-D model. Short for "object file," OBJ files often include information about surface color and texture in an attached MTL ("material") file. This makes them useful for applications like game design, but less suited for 3-D printing.
- **Orientation** - The rotation and position of the 3-D model. Some orientations are better-suited for 3-D printing than others (for example, having a flat side of your model on the bottom is generally a more stable orientation).
- **Slicer** - Software that converts STL files or other 3-D model formats into G-code files for 3-D printing.
- **STL** - A digital file format for a 3-D model, imported into a slicer to convert it to G-code. STL is short for "stereolithography," an older 3-D printing technology. STL is one of the older 3-D file formats, and just contains data on the shape of an object, without any color or surface data, making it an efficient file type for 3-D printing.
- **Support** - Removable and discarded 3-D printed material used to prop up overhangs, bridges, and negative space during printing.

Derived from Budmen. (2019). Preparing your model for 3-D printing. https://budmen.com/support/3d-course/lesson-4/

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PROPOSED ACTIVITY

1. For understanding process, students will prepare their designs for 3-D printing:
   - Go through the handout and play around with example parts.
2. Students will prepare the STL file for its printing:
   - Use the computer and follow the instructions to create the STL file from their model.
3. Students will prepare the print by experimenting with different print settings:
   - Use the example models to understand how each setting influences the print time and surface finish.
4. Learn about **part orientation** by modifying the settings.
5. Learn about **infill density** by modifying the settings.
6. Learn about **layer thickness** by modifying the settings.
7. Learn about how to use the **print preview** to achieve a desirable result.

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Module V: Case Study

SOPHIE KAHN

Visual artist Sophie Kahn challenges the ways in which, usually, artists and designers make use of the 3-D printing and 3-D scanning technologies. By misusing advanced 3-D laser scanners with the goal of generating glitchy outcomes,

Kahn aims not at fabricating formally correct 3-D printed objects; instead, she creates defective files of failed 3-D scans to print as incomplete or imperfect sculptures. Following other glitch artists, Kahn defies the idea that technology and production (and in this particular case, digital fabrication) need to be flawless.

Kahn utilizes not only 3-D scanning and 3-D modeling techniques as part of her design process, but she also incorporates the post-production stage as part of her artistic practice. It is through the digital alteration of her defective files that Kahn's artworks can materialize.

Figure 1. Repaired glitchy 3-D digital model being exported into a STL file for printing.

Figure 2. "Torso of a Woman (II), Degraded Fragment." 3-D print from 3-D laser scan, gesso, watercolor pigment.

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Module V: Case Study

PROJECT DESCRIPTION

Industrial and technological development has largely focused on developing the ability to increasingly produce larger numbers of flawless products. However, glitch artists question this assumed value. Glitch artists think that technology-driven production is more complex than just the search for visually or technically correct results, which they call “an elitist discourse and dogma widely pursued by the naive victims of a persistent upgrade culture” (Menkman, 2011, p. 339).

In order to question perfectionist assumptions in digital fabrication technologies, visual artist Sophie Kahn creates sculptures born from failed technological processes. In her process, she purposefully misuses 3-D scanners by moving the scanned subjects, in order to produce the glitchy 3-D files that will then become her art pieces.

After the scanning takes place, Kahn begins the post-production process. When flawed 3-D scans are imported as digital models into 3-D modeling software, they cannot become printable files without going through a repair process. Kahn has to fill empty spaces in the scan, fix imperfect edges, and smooth ruptured surfaces.

However, Kahn manipulates these digital processes designed to repair her imperfectly 3-D scanned models, in order to maintain the original glitches, holes, and imperfections of the scans while still producing a 3-D printable file.

This way, Kahn fabricates artworks that can question culture’s focus on achieving perfection through technological improvement: “an incomplete 3-D scan reveals the incompleteness of human vision; made from a single perspective, it only takes a slight rotation to reveal the gaps and blind spots, all the things we do not see” (Kahn, 2017).

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Module V: Case Study

REFLECTION QUESTIONS

1. Technically, Kahn's work relies more on the post-production process than the modeling process. How could you incorporate other post-production processes (such as manipulating support materials, layer thickness, or infill density) into the creative practice of producing a 3-D printed object? Is there a way you could do them "wrong" that might have interesting results?
2. Kahn's artworks prove that sometimes errors con become virtues. Considering the potential technical errors that can take place when 3-D modeling, scanning, and printing, what other creative uses of technical errors in digital fabrication con you think of?
3. How con workflow mistakes in processes involving, among others, layer thickness, printing speed, or infill density affect a 3-D model's chances of being successfully printed? Are there any errors that are so dire that they cannot be turned into art, or is any mistake an opportunity?

REFERENCES

Menkman, R. (2011). Glitch studies manifesto. In G. Lovink & R. S. Miles (Eds.), Video vortex reader II: Moving images beyond YouTube (pp. 336-347). Institute of Network Cultures.

Kahn, S. (2017). On Preserving the Glitch. In M. Allahyari, D. Rourke, & M. Rosch (Eds.), The 3-D additivist cookbook (pp. 327-329). Institute of Network Cultures.

IMAGE ATTRIBUTIONS

Figure 1. Retrieved from The 3-D Addivist Cookbook. https://additivism.org/cookbook

Figure 2. Photograph by Danielle Ezzo. https://www.sophiekahn.net/torso-of-a-woman-sculpture

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Module V: Handout

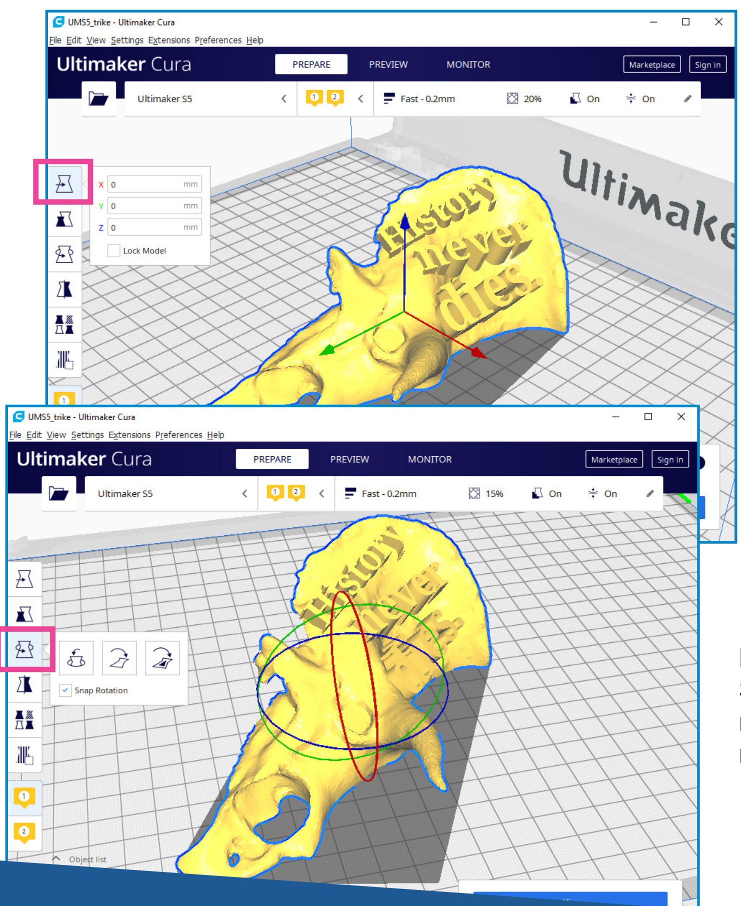
ADDITIVE MANUFACTURING

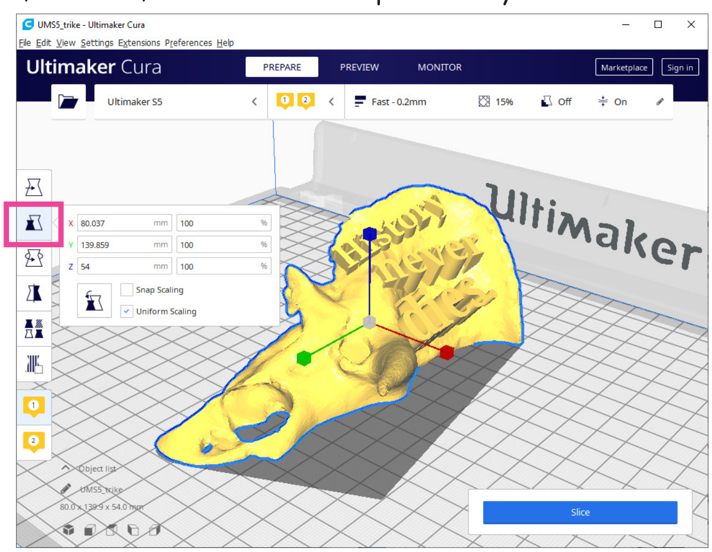
Also known as 3-D printing, additive manufacturing is the process of manufacturing parts by adding material layer by layer. The quality, print time, and the material usage for these 3-D printed parts depend on various manufacturing process parameters. An understanding of these parameters and how to manipulate them can help artist achieve their desired outcomes with 3-D printing, as well as experiment with the processes (as Sophie Kahn does).

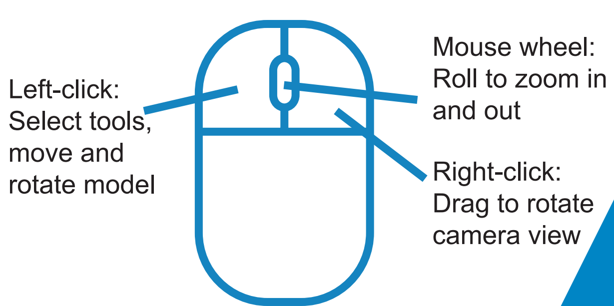
USING SLICER SOFTWARE

There are a variety of free slicer software tools available. These include Slic3r and Cura, among others. In this tutorial, we will be using Cura, but other tools can also be used successfully.

1. Open Cura, and open an STL file in the program. Use the tools on the left, as illustrated below, to control the view of the model. Move, Rotate, and Scale the part as you wish.







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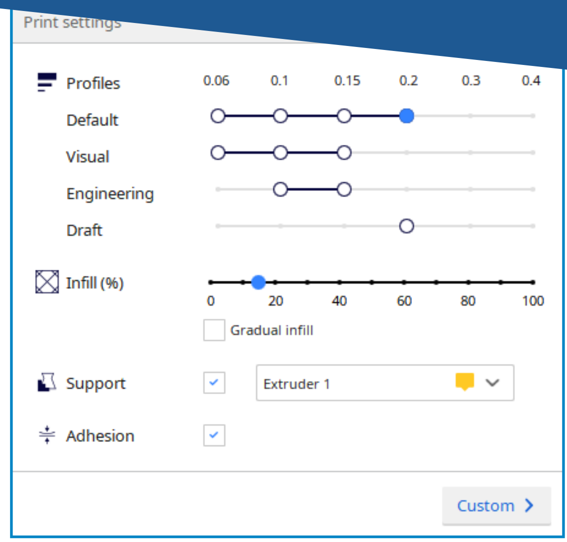
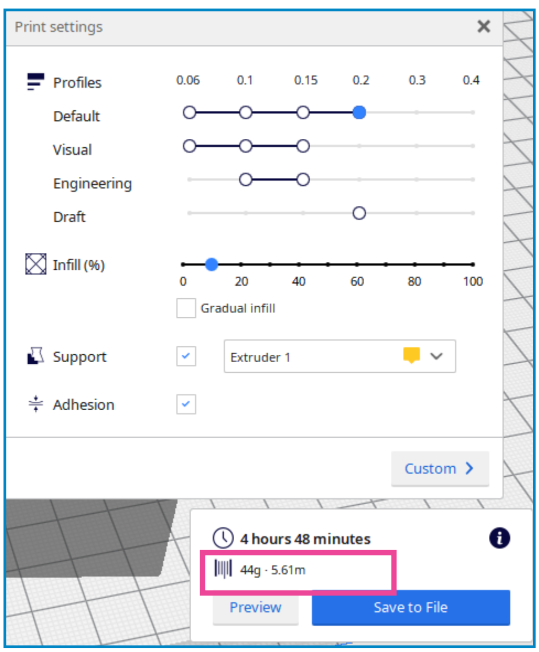
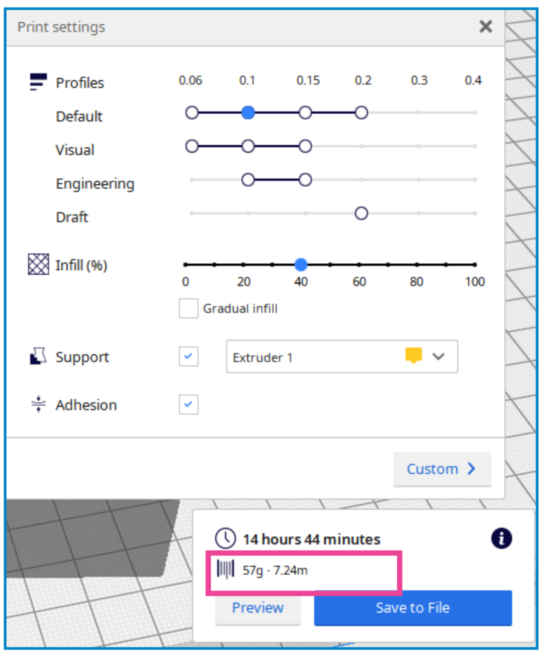
2. Click on the settings at the top of the screen to adjust the **Print Settings** regarding layer height, infill, and supports.



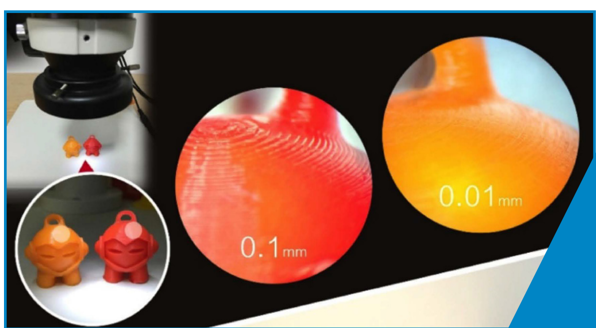
3. Click the **Slice** button in the bottom-right. The program will work for a moment generating a 'sliced' version of your model.

   It will also create a time estimate for your print. Experiment with different layer thicknesses and infill densities (as well as different scales and rotations), and notice how the estimated print time varies.





Choosing a layer height involves a trade-off between smoothness of the final print (right) and length of time the print takes (above).
What layer height best suits your model?



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4. If you click the **PREVIEW** button at the top of the screen, you can see the 'sliced' version of your model, as well as any supports that will be produced in the final print. In the image below, notice how the horn of my dinosaur skull now has supports.

5. You can also drag the slider at the right to see the different layers of your model, including the infill.

6. When your print quality and print time suit the needs for your project (or for your class's requirements), you can press **Save to File** to export the **g-code** file to send to the printer.