MODELING FORM

Module II: Lesson Plan

MODULE GOALS

In 3-D printing and **additive manufacturing**, a three-dimensional object is created from a digital model that has been designed on a computer. **Computer-aided design** (CAD) and modeling programs like AutoCAD, Sketch-up, and TinkerCAD are used to create these digital forms that contain the information from which an object is printed. In this module, students will use the TinkerCAD platform to build new digital forms by **remixing** pre-existing digital models. In doing so, they will be able to identify some of the differences between digital and real-world modeling, and learn how to navigate the various applications available through computer-aided design. They will also learn how appropriation and remix as creative tools can play a part in 3-D modeling, as they do in other forms of digital creativity.

ESSENTIAL QUESTIONS

- How do we turn a design idea into a digital model using computer-aided design programs?
- What are the capabilities that TinkerCAD offers as a digital design program? What other design tools are out there?
- What are the advantages and limitations of designing objects digitally versus creating an object in the physical world?
- What possibilities are we presented with through the digital creation of 3-D objects that change the way we produce resources for the public?

MEANING AND ACQUISITION

- Students will have a basic grasp of the tools available in computer-aided design programs and how to use them.
- Students will experience and understand the process of turning an abstract idea into a digital model.
- Students will gain experience in building 3-dimensional objects in a digital space using additive and subtractive modeling techniques.
- Students will understand the role computer-aided design plays in the overall process of additive manufacturing.
- Students will explore the distinct potentials afforded by digital modeling, specifically the ability to remix pre-existing forms.

MODELING FORM

Module II: Lesson Plan

FORMATIVE ASSESSMENT STANDARDS

- Students demonstrate active problem-solving skills throughout the modeling of their design into a functional digital form **(Cr2.1.8a)**.
- Students know and use fundamental vocabulary relevant to CAD and the TinkerCAD platform **(Cr3.1.1a)**.
- Students actively consider the practices, issues, and ethics of appropriation, fair use, and open source as they apply to creating digital designs and 3D-printed objects, and to accessing repositories of publicly-available models and scanned artifacts **(Cr2.2.8a)**.
- Students are able to discuss and explain CAD processes and techniques to their peers and help facilitate peer-to-peer learning **(Cr1.1.II)**.

SUMMATIVE ASSESSMENT STANDARDS

- Student work demonstrates relationships among form, context, and purposes **(Cn10.1.5a)**.
- Student work delineates a unifying concept through the production of a design that reflects skills in iterative processes using traditional and contemporary technologies **(Cr3.1.8a)**.
- Student work exemplifies an effective use of materials, equipment and tools into the production of design forms **(Cr2.1.IIa)**.
- - Student work exemplifies a synthesis between creative and analytical principles and techniques of the visual arts and the sciences **(Cr2.3.IIa)**.

MODELING FORM

Module II: Lesson Plan

MATERIALS

- Laptop/iPad/Chromebook and mouse
- Internet Access
- TinkerCAD (and free accounts set up for student access)
- Projector (for instructor demonstration)

KEY TERMS

- **Additive manufacturing** - Also known as 3-D printing or digital fabrication, additive manufacturing is creating physical objects from digital data, by building up, layer by layer, building material (General Electric, n.d.).
- **Computer-aided design (CAD)** - Also known as computer-aided drafting, CAD tools are software that allow designers to draft construction documents, explore design ideas, visualize concepts, and simulate how a design performs in the real world (Autodesk, n.d.).
- **Additive sculpting** - Sculptural processes where material is added to the sculpture.
- **Subtractive sculpting** - Sculptural processes where material is taken away from the sculpture.
- **Remix** - A remix is a cultural artifact that is made from inventively combining parts of other cultural artifacts. Rooted in music remixes pioneered in 1960s-70s Hip-Hop, remixing is an active creative practice across numerous art mediums. Some artists and scholars argue that all creativity is, on some level, remixing (Navas, 2007).
- **Parametric modeling** - A 3-D modeling process where a shape has geometric parameters that can be changed numerically. For example, a gift-box might have parameters like "number of sides" to make it triangular, square, or hexagonal, as well as parameters for "depth," "width," and "height" to change its size.

Derived from:

Autodesk. (n.d.). What is CAD? https://www.autodesk.com/solutions/cad-software

General Electric. (n.d.). What is additive manufacturing? https://www.ge.com/additive/additive-manufacturing

Navas, E. (2007). Remix defined. https://remixtheory.net/?page_id=3

MODELING FORM

Module II: Lesson Plan

PROPOSED ACTIVITY

1. Students will participate in a teacher-facilitated demonstration on the basic functions available in TinkerCAD. These applications include:
   - How to utilize the library of available forms, including publicly-released artifacts from the Smithsonian collections, and **parametric** "Shape Generator" forms.
   - How to import designs from other sources for **remixing** and how to determine which file type to upload.
   - How to view your object from different angles.
   - How to change on object's orientation.
   - How to **additively** build forms in TinkerCAD (by "grouping" forms).
   - How to **subtractively** build forms in TinkerCAD (by grouping with "hole" forms).
   - How to change the dimensions and scale of your object.
2. Students will be given free time to experiment and familiarize themselves with the available tools before beginning the activity.
3. Either:
   - Students will use the available tools to remix one or more objects, either selected from the Smithsonian gallery, or imported from an external source. The Modeling Form worksheet below can be used to scaffold this activity.
   - Students will use TinkerCAD software to create a digital "next draft" of the physical prototype the developed in the previous Designing Form unit.
4. A student's design may change as they begin to understand the capabilities and limitations of computer-aided design.
5. Students will export their finished design. **(Export> "Everything in design"> STL)**
6. Students will critically reflect on and discuss the affordances and constraints of designing and building digitally versus physically.
   - If students continued developing their prototypes from the previous module, students will discuss whether and how CAD software offered different possibilities and limitations for their ideas.
   - If students remixed artifacts from Smithsonian or other collections, students will discuss the potentials (and hazards) digital modeling offers for remixing existing culture.

MODELING FORM

Module II: Case Study I

SHIV INTIGER

In 2016, artist Matthew Plummer-Fernandez created on algorithmic “artbot”* in collaboration with Julien Deswoef called Shiv Integer (Hern, 2016). The program appropriates blueprints for 3-D models found on Thingiverse, an online archive of user-mode digital 3-D models. Shiv lntiger randomly selects objects licensed for **remixing** before assembling them into dysfunctional sculptures and uploading them once more onto the Internet as new designs (Newitz, 2016). Since its inception, the artbot has received both appreciative and negative reviews by the makers and designers who hove had their projects repurposed by it (Plummer-Fernandez, n.d.).

***Algorithmic** means something that follows a specific procedure, most often a program written in computer code. An **artbot** is an automated, self-directed computer program (a “bot”) built for artistic purposes.

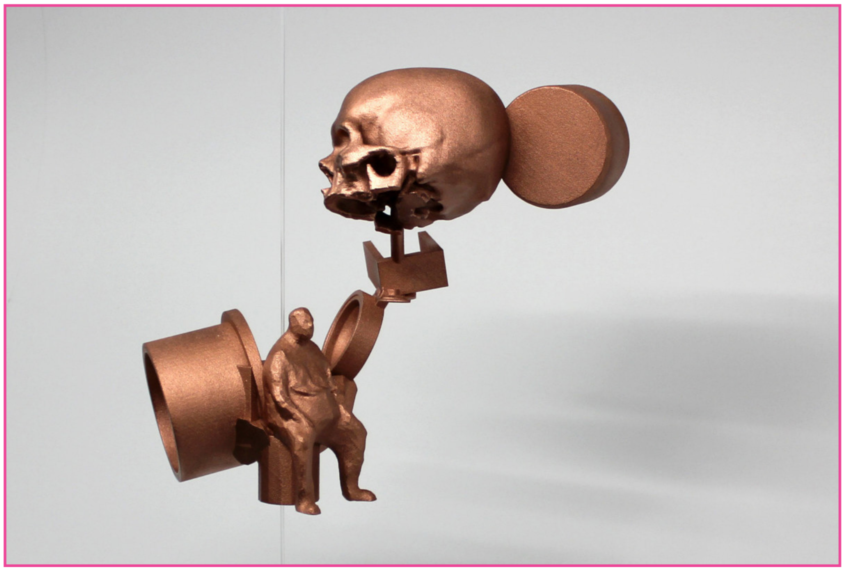


Figure 1. Tlppy PrettyTron by a filter. A 3-D print of a model generated by Shiv Intiger.

Figure 2. Webcom on und Ben. A digital 3-D model generated by Shiv Intiger.

MODELING FORM

Module II: Case Study I

PROJECT DESCRIPTION

Matthew Plummer-Fernandez, a British/Colombian artist working with various forms of sculpture, software, and online interventions, is known for work that reflects on the complexity of contemporary socio-technical relationships (Plummer-Fernandez, n.d.). Shiv Integer is one of Plummer-Fernandez's many projects that explore the possibilities offered by **computer-aided design**, dealing with the everyday entanglements of software automation in humorous and aesthetic ways. Its assemblage process is reminiscent of Dadaist readymades and chance art, and was partially inspired by the Japanese video game Katamari Damacy (Hern, 2016).

Shiv Integer is an artbot that makes assemblage digital sculpture for 3-D printers within a **computer-aided design** (CAD) environment. It does so by randomly sourcing previously designed objects from Thingiverse, an online 3D-printing community in which users can upload and share print-ready objects and engineering parts (Plummer-Fernandez, n.d.). Shiv Intiger functions by downloading digitally designed 3-D objects at random, assimilating these entities into a nonfunctional sculptural form, and re-uploading them to Thingiverse as new designs after tagging the original creators of each of the sculpture's constituent parts (Newitz, 2016). It then assigns each new creation a "word-salad" title using a similar algorithmic system (Plummer-Fernandez, n.d.).

According to artists Matthew Plummer-Fernandez and Julien Deswoef, these repurposed sculptures have had mixed reviews in the maker community (Hern, 2016). Plummer-Fernandez remarked that prior to the artists publicly claiming the venture, 'The bot ha[d] been … receiving hundreds of complaints and online harassment from the Thingiverse community, amid a few fans responding with poetry and defending its rights" (Hern, 2016). The project itself simultaneously explores the subject of authorship, appropriation, and fair use in Creative Commons licensing environments, and performs an archiving of internet subculture by orchestrating what are essentially cross-database snapshots of 3-D print culture via Thingiverse (Hern, 2016).

REFLECTION QUESTIONS

1. Behind Shiv Integer there is a synthesis between scientific practices (the use of programming **algorithms**, for instance) and visual arts concepts (such as **remix**). What new possibilities are opened up through the combination of activities that are traditionally considered "scientific" with ones traditionally thought of as "artistic"? What are the limitations or potential hazards of this partnership?
2. Do you think Thingiverse designers should have the right to decide how their designs are used and remixed? When remixing artifacts scanned and uploaded by museums like the Smithsonian, do you feel cultures whose artifacts might be in those collections, and who might not have agreed to their inclusion, have a right to decide how their artifacts are used and remixed? What are some of the ethical decisions, in terms of appropriation, fair use, and open source, that you believe are involved in remix exercises such as Shiv Integer? Can an "artbot" make those decisions? Who should take responsibility for the choices it makes, if they end up breaking the law, or harming or upsetting someone?
3. Are the sculptures produced using Shiv Intiger Plummer-Fernandez and Deswoef's artwork, or Shiv Intiger's artwork? How do you justify your answer? When human artists use human assistants to produce their artworks, should those assistants be credited? Should Shiv Intiger be credited?

REFERENCES

Hern, A. (2016). Move over, chatbots: meet the artbots. The Guardian. https://www.theguardian.com/technology/2016/apr/15/move-over-chatbots-meet-the-artbots

Newitz, A. (2016). That time a bot invaded Thingiverse and created weird new 3-D objects. Ars Technica. https://arstechnica.com/gadgets/2016/05/that-time-a-bot-invaded-thingiverse-and-created-weird-new-3d-objects/

Plummer-Fernandez, M. (n.d.). Works. http://www.plummerfernandez.com/

Shiv Intiger. (2016). Designs. Thingiverse. Retrieved from https://www.thingiverse.com/thing:1811207

IMAGE ATTRIBUTIONS

Figure 1. Retrieved from https://www.plummerfernandez.com/shiv-integer/

Figure 2. Retrieved from https://www.thingiverse.com/thing:1877380

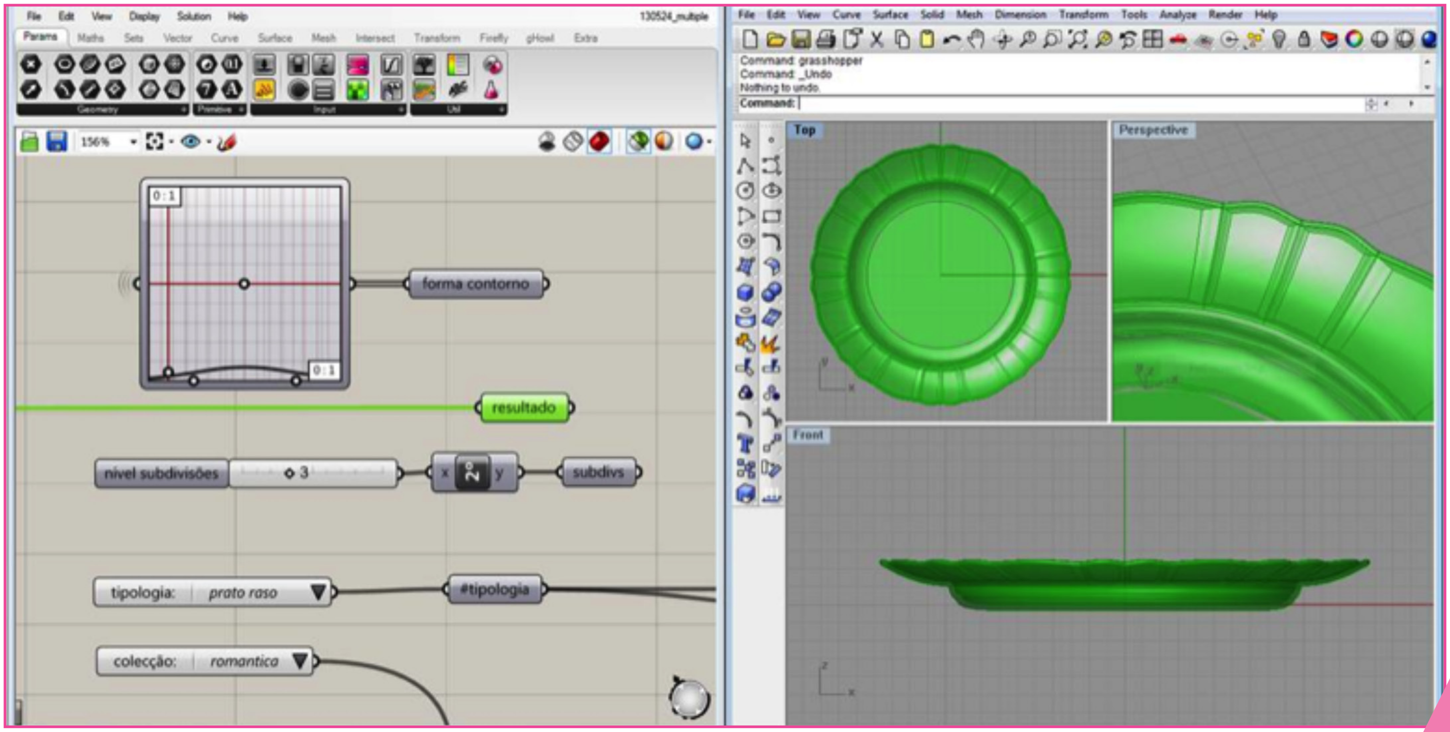
MODELING FORM

Module II: Case Study II

MASS CUSTOMIZATION OF CERAMIC TABLEWARE

Grasshopper is a program which allows for mass customization of ceramic tableware. It is a generative design process that generates geometric shapes in a **CAD**-like environment. It uses **parametric modeling**, which allow users to customize various traits, or parameters, of their tableware digitally before buying it.

These systems enable designers to create customizable tableware collections with ease and efficiency. End users (i.e. customers) can customize their final design solution through a user-centered interface that utilizes everyday language and commands. The customized digital 3-D model can then be manufactured via a production system supported by **digital fabrication**, such as a special 3-D printer that uses ceramic clay instead of plastic.



```
Command: grasshopper
Command: _Undo
Nothing to undo.
Command:
```

Figure 1 - Design system implementation in Grasshopper, showing different parameters, like curves, which can be changed (left), and a resulting plate design, displayed in the CAD program Rhinoceros (right).

MODELING FORM

Module II: Case Study II

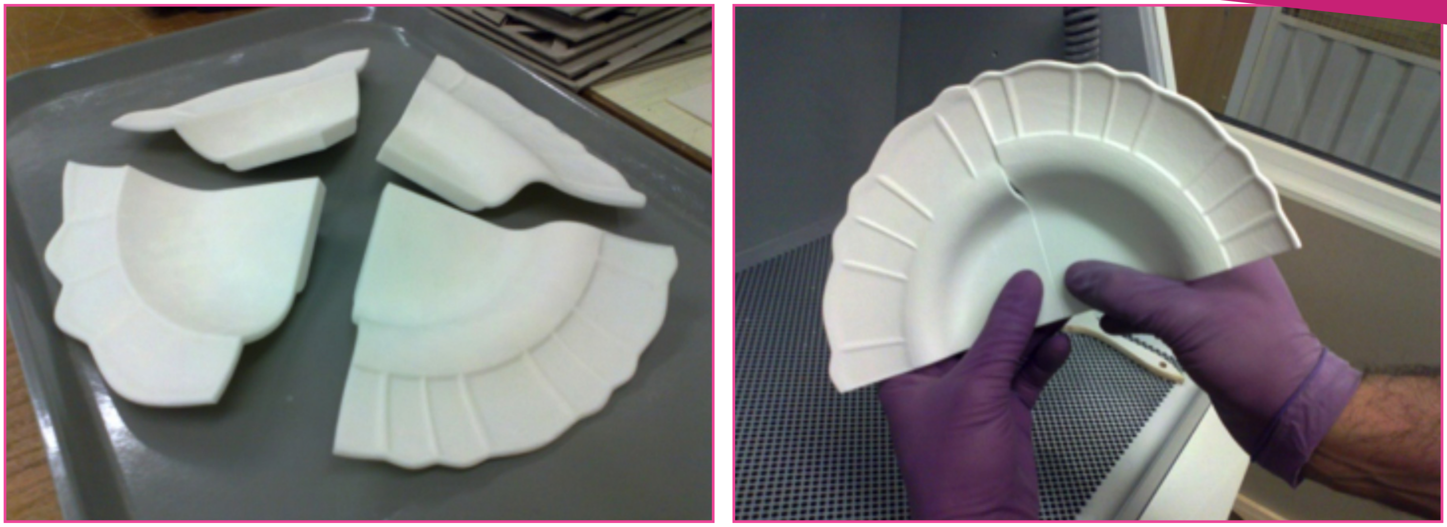
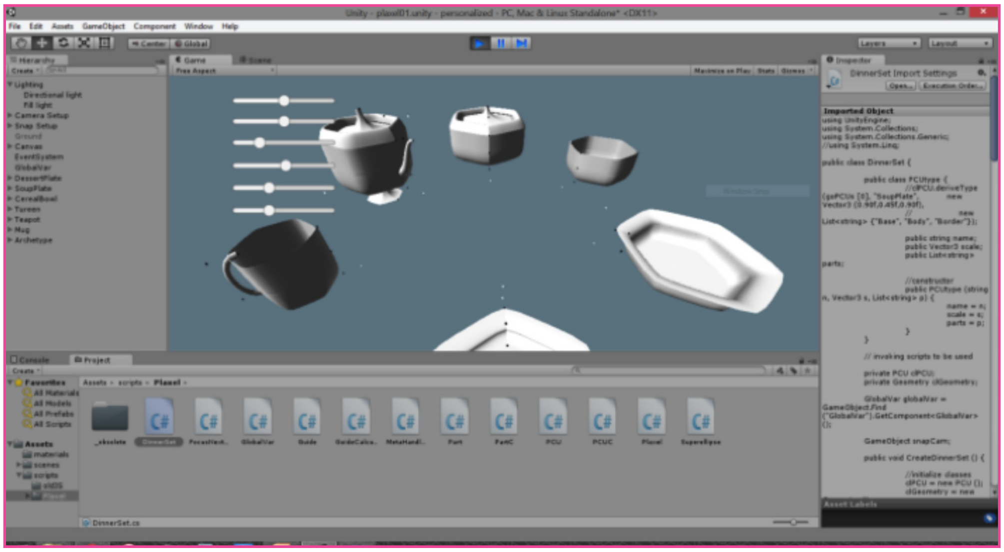


Figure 2 - 3-D printed prototypes of designs generated by the Grasshopper design system.



Imported Object

```
using UnityEngine;
using System.Collections;
using System.Collections.Generic;
//using System.Linq;

public class DinnerSet {

        public class PCUtype {
                //dPCU.deriveType
(goPCUs [0], "SoupPlate",         new
Vector3 (0.90f,0.45f,0.90f),
                //                new
List<string> {"Base", "Body", "Border"});

                public string name;
                public Vector3 scale;
                public List<string>
parts;

                //constructor
                public PCUtype (string
n, Vector3 s, List<string> p) {
                        name = n;
                        scale = s;
                        parts = p;
                }
        }

        // invoking scripts to be used

        private PCU dPCU;
        private Geometry dGeometry;

        GlobalVar globalVar =
GameObject.Find
("GlobalVar").GetComponent<GlobalVar>
();

        GameObject snapCam;

        public void CreateDinnerSet () {

                //initialize classes
                dPCU = new PCU ();
                dGeometry = new
```

Figure 3 - Design system implementation in the game engine Unity. Notice the sliders in the upper-left that users can use to adjust the various parameters, like depth, number of sides, curves, and angles, of the tableware.

Figure 4 - Ceramic extrusion (3-D printing) of creamer design generated by the Grasshopper design system (Photo by Tom Lauerman).

MODELING FORM

Module II: Case Study II

PROJECT DESCRIPTION

Researchers Eduardo Castro e Costa and Jose Duarte have
developed a research project in the field of ceramics design, focusing on the mass customization of ceramic tableware using the program Grasshopper (Castro e Costa & Duarte, 2013). The objective of their project is to grant potential designers, businesses, and customers the opportunity to design and model products according to their practical needs and personal preferences. This is done through a modeling software that uses **parametric modeling** to generate collections of digital objects that can later be taken into **CAD** environments for their manufacture. The creation of mass customizable ceramic tableware will thus allow companies in the industry to offer unique products and services to their clients (2013).

Castro e Costa and Duarte, are making use of computational paradigms such as parametric modeling and "shape grammars" to realize new ways of mass producing ceramic tableware (Stiny & Gips, 1972). "Shape grammars" means that, for example, a whole set of dinnerware (plates, teapots, mugs, and cups) can be made to fit a person with certain preferences (e.g. someone who likes sharp, angled shapes and serving large portions versus someone who likes thin curved shapes and wants long handles to serve others at a large table). Similar to how the whole grammar of a sentence changes if it is talking about "I" or "you" or "they."

The project thus anticipates a future world in which designing of everyday objects for manufacture can become a completely customizable experience according to the needs of the end user. Not only is the project planned to be beneficial to customers and designers in this way, but it also aims to improve product differentiation for the companies that will ultimately come to adopt this developed system (Castro e Costa & Duarte, 2013).

MODELING FORM

Module II: Case Study II

REFLECTION QUESTIONS

1. What other types of object might benefit from a “mass customization” model? What **parameters** would be the most useful or interesting ones to customize in that object?
2. What other uses might there be for this technology beyond making custom products for people to buy? What other fields, or other uses, might there be for easily-customized, easily-produced objects? (Are there potential medical, transportation, sport, or community uses?)
3. What are the advantages, if any, of a world where every object could be customized to your preference? What are the potential losses or problems, if any, of such a world?

REFERENCES

Castro e Costa, E., & Duarte, J. P. (2013). Mass customization of ceramic tableware through digital technology. In H. Bartolo & P. Bartolo (Eds.), Green Design, Materials and Manufacturing Processes (pp. 467-471). CRC Press. http://www.crcnetbose.com/doi/obs/10.1201/b15002-91

Castro e Costa, E., Duarte, J. P., & Bartolo, P. (2017). A review of additive manufacturing for ceramic production. Rapid Prototyping Journal.

Stiny, G., & Gips, J. (1972). Shape Grammars and the Generative Specification of Pointing and Sculpture. In C. V. Freiman (Ed.), Information Processing 71 (pp. 1460-1465). North Holland. http://home.fa.utl.pt/~lromoo/2008_09 / sg/ oulo_3/ sti ny_g i ps_oulo_3.pdf

IMAGE ATTRIBUTIONS

Figure 1. Photo by Eduardo Castro e Costa.

Figure 2. Photo by Eduardo Castro e Costa.

Figure 3. Photo by Eduardo Castro e Costa.

Figure 4. Photo by Tom Lauerman.

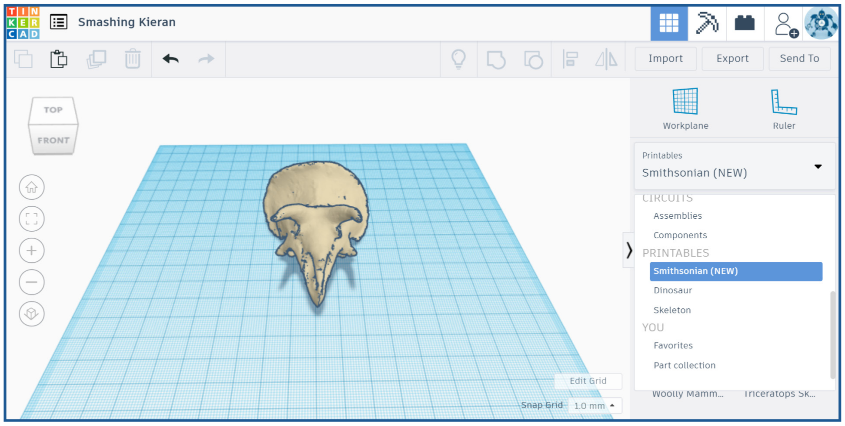
MODELING FORM

Module II: Handout

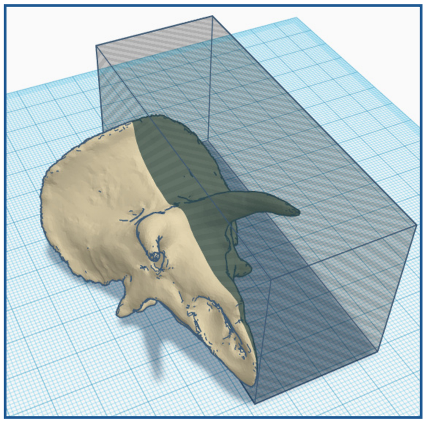
DIGITALLY MODELED FORMS

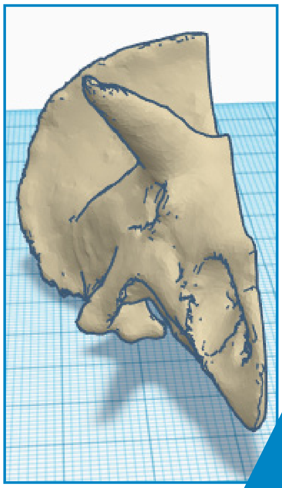
A digital model is needed in order to print objects on a 3-D printer.
Such models are created with **computer-aided design** software like TinkerCAD.

INTRODUCTION TO TINKERCAD

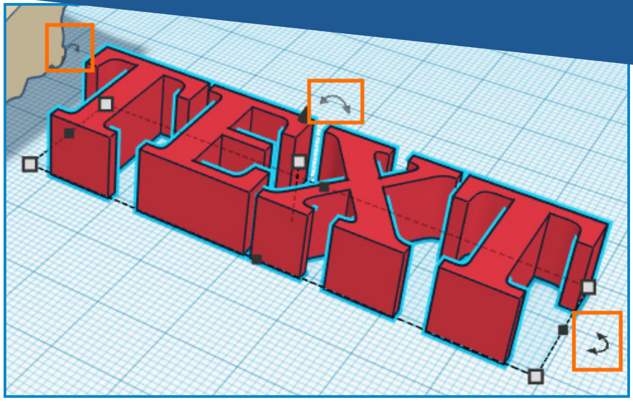


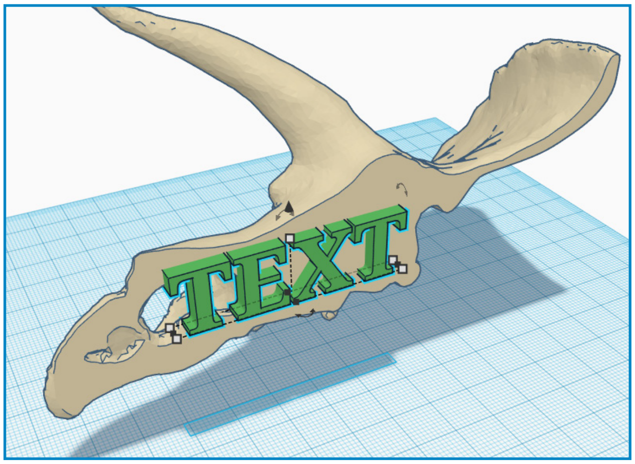
1. After logging in, click **Create New Design** on your TinkerCAD home page.
2. One the right side, click on **Basic Shapes** to explore the shape library. Click on **Smithsonian,** under **PRINTABLES**, to explore the available forms.
3. Choose an artifact and drag it into the workspace.
4. Practice navigating the workspace by **right-clicking and dragging to rotate**, rolling the mouse wheel to zoom in and out and clicking and dragging the mouse wheel to pan left, right, up, and down.
5. To practice **subtractive sculpting**, return to **Basic Shapes** and drag a **Box Hole** (the gray, stripey box) into your workspace.
6. You can drag the box to position it, and drag the small squares on its edges, corners, and top to resize it. Align the box so that half of your chosen object is inside of it.
7. Holding **SHIFT**, click on both the artifact and the ‘hole’ so they are both selected. Then, in the upper-right, click **‘Combine’**
   (), and your shape will be cut in half! (It may take a few seconds to work first. Be patient.)
   This tool is very powerful - you can turn **any** shape into a hole and use it to subtract material from any other shape!



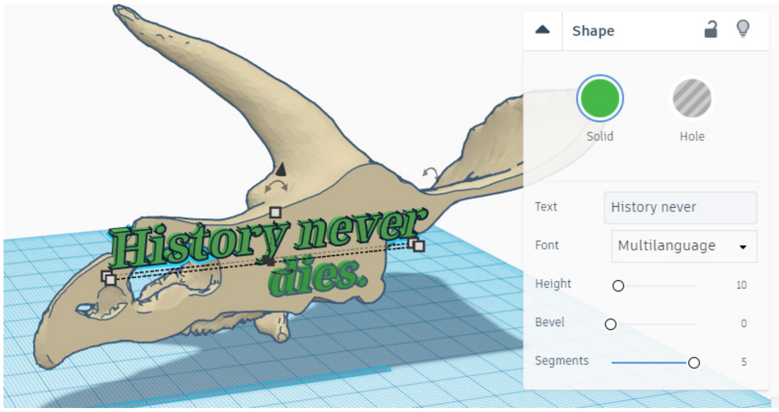


8. Now for some **additive sculpting.** Drag and drop the TEXT shape from the library of shapes on the right side of screen.
9. You can **resize** and **reposition** your text using the same tools we used above. You can also **rotate** the text by clicking on the small curved arrows on each side of the model.
10. Our goal is to position the text so that it is against the new, flat side of our sliced shape.





11. Now, edit the text in the "Shape" window in the upper-right of the screen. What could you write that would change the meaning or impact of the object you chose?



Text: History never
Font: Multilanguage
Height: 10
Bevel: 0
Segments: 5

12. You can continue to experiment with **remixing** your form. How might further **additive** and **subtractive** choices transform it into something new?
13. When your design is complete, click **"Export"** in the upper-right of the screen, select **"Everything in the design,"** and save your file as an .STL for printing.