

The **Box Project** facilitator guide serves as a companion to the step-by-step directions on The Additive Project website. It is intended to guide facilitators through setting up the workspace, leading participants through the project and debriefing the experience. This exercise is best offered following The Additive Project's **Keychain Project**, which teaches participant some basic tools and leaves them with an object to sue on the box or pendant, and prior to the **Custom Box Project**, in which participants' projects can be customized and all skills and tools learned so far can be reinforced.

The **Box Project** provides several options for creating a multi-piece object and introduces shelling.



LEARNING OBJECTIVES

- Open Image in Illustrator
- Create Vector Outlines in Illustrator
- Export SVG from Illustrator
- Import SVG into 123D Design
- Reinforce How to Extrude Objects
- Learn Shell Tool
- View Transparent

PROJECT OVERVIEW

- Introduction
- Overview of Prototyping and Uses of Customization (Optional)
- Skills Lesson 1
- Project Work Round 1
- Skills Lesson 2
- Project Work Round 2
- Debrief + Class Summary

SKILLS OVERVIEW

This project was developed for use with Adobe Illustrator + Autodesk 123D Design. Below are some of the skills that will be learned or reinforced through the introduction and/or repeated use of the relevant tools. Videos are available for view in the Tutorials + Tool Tips sections included in the step-by-step.

PROGRAM BASICS

ILLUSTRATOR

Preparing images in Illustrator for 123D Design

- Deleting anchor points to simplify images

SVG FILES

Converting Illustrator files into SVG format

- Opening a 123D File

DELETING ITEMS

Discard unwanted pieces from the workspace

- Deleting Objects

VIEWING + MOVING

CAMERA ROTATION TOOL

Make adjustments in the camera view.

- Using the Orientation Tool

ZOOM

View objects close up or at a distance.

- Zoom Tool

VIEWING + HIDING SKETCH

Choose to view a sketch template or hide it.

- Show/Hide Tool

PREP + MATERIALS

CLASSROOM RESOURCES

COMPUTER ACCESS:

Each participant should have his or her own computer for the duration of the project.

PRESENTATION + LECTURING:

Ideally, you should be able to play the Tool Tips videos and walk the class through each Module by demonstration on a projector that all participants can see.

SOFTWARE REQUIREMENTS:

This project requires each computer to have Adobe Illustrator + Autodesk 123D Design installed and available.

TEMPLATE REQUIREMENT:

This projects requires each student to have the ability to access and open The Additive Project Keychain, a 123D file. This can be done via the internet from The Additive Project site if access is available. Alternatively, you may download the file and preload it onto computers where the participants will have access.

PRINTING REQUIREMENT:

Currently, this project outlines the process for printing using the MakerBot Printer.

TIME

The lesson is designed to take 45m-1h, depending on:

- The inclusion of the introduction
- Time spent on going over skills training
- Time spent on optional learning activities
- Time spent debriefing

PRINT TIME

The Box + Pendant Project has been tested to create a viable object with a print time of 20m or less. This can be done at the end of the lesson or during another class period. The size and duration of the print is flexible and based on your access to printers.

SUGGESTED PROCESS

INTRODUCTION MODULE (OPTIONAL)

Show the “Pointilism to Paint by Number” slideshare to help facilitate an understanding of what vector art is and why it is applicable to the 3D printing process.

PROJECT FACILITATION

Direct participants to the project website. Introduce or review the project page components which they can use as reference reviewing the step-by-step instructions, the location of the required files (these may be on their desktops if previously installed), and the Tool Tips + Tutorials section.

OPTION 1: With groups that do well independently you may choose to begin the session by giving an overview of The Box Project learning objectives, as well as the tools needed to complete the project. Additionally, you might identify the goals, play the tutorial videos, and let participants follow the step-by-step on the site.

OPTION 2: Alternatively, break the session up into smaller segments which each include several steps involving particular skills and allow for break points to check with participants and teach the following module's new skills before progressing. Play Tool Tips Videos and allow participants to follow the steps on The Additive Project website, play tutorial videos, or demonstrate the steps to the class using projection.

MODULE 1: CONVERTING AN IMAGE INTO THE SVG FORMAT (OPTIONAL)

Steps 2-4. These optional steps are designed to teach participants how to locate images online and prepare them for 3D printing. This section covers basic Adobe Illustrator preparation work which can be emphasized or expanded depending on your program's needs and focus. Alternatively, The Additive Project website has a few basic SVG files that can be used to complete this project.

MODULE 2: CREATING THE BOX + LID

Steps 5-6. Importing an SVG into 123D; extruding the shape to create a 3D object. At this point there are two options for proceeding. The Shell Option should work for most simpler images, particularly those that do not contain many sharp, tight angles or curves; the Copy, Scale + Merge Option can be used for more complex shapes.

NOTE: Keep in mind that if some students using the Scale Option, that process is simpler and therefore faster, meaning they will have downtime as you guide others through the Copy, Scale + Merge Option. Also, some may attempt the shell technique only to discover it doesn't work and have to regroup and proceed with the scaling technique.

SUGGESTED PROCESS

MODULE 2: SHELL OPTION

Steps 7-8. Using the Shell Tool to hollow out the object and create a uniform thickness on 5 sides; participants should proceed to Step 7 Option 1 from here. This is the simpler method if it works with the images selected by participants. Extruding + shelling the sides of the lid for depth; extruding the base above the lip to create a plug on the lid using the Pull Tool.

MODULE 2: COPY, SCALE + SUBTRACT OPTION

Steps 9-10. Using scaling to create a smaller representation of the object which is then subtracted from the original object; participants should proceed to Step 7 Option 2 from here. Extruding the box lid; copying + pasting a duplicate; scaling down the duplicate to create the plug; positioning and merging the plug piece with the lid.

MODULE 3: EXPORT AS TWO OBJECTS

Step 8. Saving the objects separately; exporting to print. Ensure all participants have completed this step before proceeding. If more than one object exists in the file 123D will not export both and will export only one of the items which is why it is easier to delete one object and export then revert and delete the other item and then export to insure that both parts have been exported.

MODULE 4: PRINTING

Step 9. Importing both objects into print software; arranging them on the print bed; scaling for print; printing.

FACILITATOR STEP-BY-STEP

INTRODUCTION MODULE (OPTIONAL)

GOAL

Gain a basic understanding of what vector art is and why it is applicable to the 3D printing process. To begin to understand how images can ultimately be transformed into 3D objects.

MEDIA

Show the [Pointillism to Paint By Number](#) slideshare.

TALKING POINTS

- This project will focus on creating a small box and lid. The project is designed to introduce some tools and skills that will help you use find an image you like on the internet and, if necessary, create source files from Illustrator that will can be imported for use in Autodesk 123D. You will be able to reference step-by-step instructions, tutorial videos, and tool-tips on The Additive Project website.
- In general, 3D modeling apps cannot import the most common image formats you find on the internet, such as JPEG, GIF or PNG.
- For images to be made into objects in a 3D graphics program, they need to be turned into a format called SVG.
- SVG stands for Scalable Vector Graphics. SVG is a format for 2-dimensional images that can be created in text or with drawing software, and can be searched, indexed, compressed and scripted.
- [Pointillism to Paint By Number Slideshare](#) Talking Points by Slide:
 - ⇒ Slide 1: Pointillism is a style of art where the painter builds the painting through more and more individual dots of color. This is very similar to the way that most digital images are constructed except instead of dots of paint they are pixels.
 - ⇒ Slide 2: To the computer an image looks like a series of blocks with individual information for the color of the block
 - ⇒ Slide 3: When put together the blocks form the image as we understand it, but a computer does not recognize the edges of the image you see here. It merely knows each block of information in the grid
 - ⇒ Slide 4: If we were to try to extrude this information in a 3D program it would be much like pin art in that we would have to give information for each individual pixel which would be incredibly time consuming
 - ⇒ Slide 5: The type of image we just outlined is what is called a raster graphic. Another kind of image is a vector image or SVG. In this type of image the image is made up of a series of points and information regarding the lines in between them.
 - ⇒ Slide 6: This type of image is more similar to a paint by numbers where the image is made up of a lot of lines defining areas and then filled in
 - ⇒ Slide 7: This type of image makes it possible to extrude shapes and not pixels
 - ⇒ Slide 8: The information for those shapes is very similar to a connect the dot picture
 - ⇒ Slide 9: The information for the lines connecting those dots then creates the shapes and image.
 - ⇒ Slide 10: What we can do to an image that is the raster format or pixel pointillism is to digitally trace the edges of the shapes that we want to then be able to bring them into the 3D program and manipulate them.
- SVGs have a benefit over other image files because they are scalable vector images allowing you to scale them without losing much definition.
- Being able to work with SVGs in the 3D software allows you to take, or make, a line drawing like a logo or symbol and create something.
- When tracing images (like the cat in the last slide), it is generally easier to do with bold high contrast images where it is easy to tell where the outlines will be.

FACILITATOR STEP-BY-STEP

MODULE 1: CONVERT IMAGE INTO SVG (OPTIONAL)

GOAL

Successfully Download an Image from the web and convert it to the SVG format.

MEDIA

- Play the Tutorial: *Select Object/Image Trace/Make*
- **OR** Demonstrate downloading an image, opening it in Illustrator for manipulation and conversion into the SVG format.

TALKING POINTS

- The Additive Project has a number of PNG images for download that work for this process. Navigate to the site and find the Box Project Page. Under the Required Files tab, located the PNG files and choose one you like.
- The files must be converted into SVG files. SVG stands for Scalable Vector Graphic. This is a necessary step because 3D software cannot recognize other image file formats.
- Think of a normal image as a bunch of points next to each other that make up the image (pointillism) while an svg is a bunch of lines with areas filled in that make up the image (paint by numbers).
- Open up Illustrator and access the file you downloaded.
- Select the object from the Artboard (screen), then find Object on the top toolbar. Select Image Trace in the drop down menu, and then Make. This is essentially the computer tracing the image you imported to turn it into a paint by number object.

MEDIA

- Play the Tutorial: *Clean Up Object*
- **OR** Demonstrate opening the Layer Bar and cleaning up anchor points

TALKING POINTS

- Illustrator may not always get the trace perfect or may make the trace more complicated than it needs to be, particularly for the end use of 3D printing.
- Once you have traced the image, you want to view the new trace to see how well suited it is for our purposes.
- Each separate trace will be a separate layer. These can be viewed in a list on the side. In some cases the trace will make extra traces that you don't need
- Each individual trace will be made up of anchor points. These points and the trace are similar to a connect-the-dots image that informs how shallow or steep curves and angles are drawn.
- Each point in the image will correspond to an angle in the 3D object, so where a line is

FACILITATOR STEP-BY-STEP

essentially straight or has a uniform arc, multiple points would correspond to many faces on the object in 3D. Too many faces will lead to a cumbersome, overly complex object that will slow or crash the software.

- The goals of cleaning up these points are:
 - ⇒ To make the trace look like the image you wanted;
 - ⇒ To simplify the image, making the manipulation of the trace in the 3D program as simple as possible.
- First, open the Layers Menu in Illustrator to find and delete any extra layers that were created that aren't required for your image. If deleting a layer alters the image in a way you don't like, Command + Z will undo the action.
- Before proceeding, make sure you have isolated the layer and object you want to clean up and select it in the active screen.
- Select the path Delete Anchor Point Tool and go over the whole object looking systematically for unnecessary anchor points. If deleting an Anchor Point alters the image in a way you don't like, Command + Z will undo the action.

MEDIA

- Play the Tutorial: *Save as SVG*
- **OR** Demonstrate saving the object in Illustrator.

TALKING POINTS

- Once all modifications are complete + extra anchor points are deleted, select File + Save As from the top toolbar.
- Under Format in the dashboard that appears, drop down and select SVG. Save the file in an easily accessible place on the desktop as it will be accessed through 123D in the next step.

STEPS COVERED IN MODULE 1

Participants should have completed the following steps when you are ready to move on:

Step 1. Select Object/Image Trace/Make: Download image; open in Illustrator; Artboard, Object, Image Trace; Make and Expand

Step 2. Clean up the Outline: Check layers in Layer Bar; use Delete Anchor Point Tool to go through; remember ctrl + z for undo

Step 3. Save as SVG: Save As; make sure to select SVG

FACILITATOR STEP-BY-STEP

MODULE 2: CREATING THE BOX + LID

GOAL

Extrude the Image Outline + Create a Shell for the Box Bottom

MEDIA

- Play the Tutorials: *Open SVG in 123D + Extrude Object to Desired Height*
- **OR** Demonstrate opening 123D, importing the SVG, and extruding

TALKING POINTS

- Once an SVG has been prepared and saved, it can be imported for use in 123D.
- Open 123D and access the Main Menu under the logo. Select Import SVG as a Sketch and navigate to the image file you saved. (Import as a Solid will automatically extrude it which you may not want to do before you see what the import looks like.)
- Once it has appeared in 123D, the shape represents the outline of the bottom of the box.
- Select the shape and use either the pop up toolbar or the Construct Tool on the top toolbar to locate the Extrude Tool. The Extrude Tool will work the same way as it does for text, “pulling” the two dimensions into a three dimensional object. Pull up to a height of about 10mm or type 10mm into the extrude dash.
- Depending on the complexity of the shape you have chosen, there are two options for proceeding to hollow out the object.
- **Option 1** uses the Shell Tool. This is the simplest option and is useful for objects with uniform angles and curves. Once you have selected a face, it uses the outside faces of the object to create a uniform wall on 5 sides of the object. Because it seeks uniformity, tight corners can cause it to fail.
- **Option 2** uses the Scale Tool. This often works better for more complex objects with tighter corners and curves. It involves creating a smaller scaled object which is then subtracted from the original.
- *Walk through the class, making an assessment of which option participants should use.*

STEPS COVERED IN MODULE 2 (GENERAL)

Participants should have completed the following steps when you are ready to move on:

Step 5. Open SVG in 123D: Main menu; Import SVG

Step 6. Extrude Object: Select object; choose extrude; raise to 10mm

MODULE 2: SCALE OPTION

MEDIA

- Play the Tutorial: *Option 1 Shell Tool Step 1*

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- **OR** Demonstrate using the Shell Tool

TALKING POINTS

- Make sure you are in Home View and select the top face of the object. In the popup tool that appears, select Shell.
- The object will be hollowed out and you will see an arrow on the interior. You will also see a toolbar denoting the thickness of the walls. These will allow you to adjust the thickness of the sides and bottom of the object.
- A thickness of 0.5mm is generally good for our purposes and can most easily be achieved by typing .5 into the field marked Thickness Inside.
- **NOTE:** If a participant completes the adjustment of the thickness of the walls with the drag arrow, but then reselects the same face in an attempt to change it again, s/he can end up hollowing out the wall itself. Remember Ctrl + Z to undo.
- *Make sure the participants write down the thickness they chose for the sides of the box as you will need it for reference when making the lid.*

MEDIA

- Play the Tutorial: *Option 1 Shell Tool Step 2*
- **OR** Demonstrate extruding, shelling and press/pull for the lid

TALKING POINTS

- If you used the Shell Tool for the bottom of the box, it is possible to use a very similar method to create the lid.
- Move the box object away from the sketch by selecting Move and dragging it out of the way. Select the shape again and repeat the steps above for creating an object from the 2D shape, i.e. select the Extrude Tool from the pop up toolbar and drag upwards or type. A depth of 2mm usually works well for the lid.
- Select the top face and use the Shell Tool once again.
- This time, because the interior of the lid is actually going to protrude, the thickness of the sides should be slightly greater than those of the box itself. A thickness of 0.5mm greater should work.
- Now that the sides are in place, the object is like a shallow box. For the lid to stay in place on the box, we will invert the object. This is best done from Home View or at least from an angle.
- Select the bottom, inside face, or “floor”, of the object. In the pop up menu that appears, select the Press/Pull Tool.
- With the arrow that appears, pull the bottom upwards so that it protrudes from the lid. This protrusion is now slightly narrower than the interior opening of the box itself but should

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be snug enough to keep the lid in place.

STEPS COVERED IN MODULE 2: SHELL OPTION

Participants should have completed the following steps when you are ready to move on:

Option 1 Shell Tool Step 1: Select top face; select shell tool; adjust to .5mm

Option 1 Shell Tool Step 2: Drag object; extrude sketch; shell + make sides thicker; select floor; Press/Pull tool to pull out.

MODULE 2: SCALE OPTION

MEDIA

- Play the Tutorial: *Option 2 Copy, Scale + Subtract Step 1*
- **OR** Demonstrate using the Scale + Subtract Tools

TALKING POINTS

- If your object requires the use of the second option, begin by selecting the object and copying + pasting. Remember that the new, pasted, object appears exactly where the original is on the grid plane. Use the move arrows that appear to drag the object away from the original.
- Re-select the object and use the pop up toolbar to choose Scale. Leave the Scale Tool on its default Uniform setting.
- Push the object in on itself with the scaling arrow or use the dash to type a factor of 0.9 or so to scale the object down a bit. Write down the factor you type in as you will need it for reference when creating the lid.
- Remember, this new object represents the material that will be subtracted from the interior of the original to make a box, so you are determining the size of negative space.
- Once it is scaled, select the Move Tool again and drag the object back inside the original. You may need to return to Top View to ensure that the smaller object sits evenly inside the larger.
- Because the new object was scaled uniformly, it shrank on all sides, meaning it must be raised up to protrude from the original, larger object. When this object is subtracted from the original, the face from which it protrudes, or sticks out, will be the opening of the box. Return to Home or a side view to complete this function.
- Locate the Combine Tool and select Subtract.
- When using the subtract tool, remember that the first option selected—the Target Solid—is the target to be subtracted from, in this case the larger object. The Source is the object that represents the material to be taken away, the smaller object. Select the larger shape first, then the smaller object inside and hit enter to complete.

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MEDIA

- Play the Tutorial video for Step 7 Option 2
- **OR** Demonstrate using the Copy, Paste, Scale + Merge Tools

TALKING POINTS

- If you shelled the box using Option 2 with scaling, the process for creating the lid is almost the same, diverging only in that you will merge instead of subtract.
- Drag the box away from the sketch, reselect the sketch and extrude to about 2mm.
- Reselect the new lid object and copy + paste.
- Drag the pasted object away from the lid, reselect the new object and choose the Scale Tool from the pop up toolbar.
- Use the Scale Tool menu to type in a factor slightly smaller than the one used for the piece subtracted from the box as this object will eventually have to fit snugly into the space left by that one.
- Once scaled, drag it next to the lid object and use the Orientation Cube to change your view to a side view, looking level with the grid plane.
- Use the Scale Tool menu to type in a factor slightly smaller than the one used for the piece subtracted from the box as this object will eventually have to fit snugly into the space left by that one.
- Once scaled, drag it next to the lid object and use the Orientation Cube to change your view to a side view, looking level with the grid plane.

STEPS COVERED IN MODULE 2: SCALE OPTION

Participants should have completed the following steps when you are ready to move on:

Option 2 Copy, Scale + Subtract Step 1: Copy + paste; drag new object away; uniform scale to 0.9-0.95; drag inside original; center in top view; raise up in side/home view; subtract

Option 2 Copy, Scale + Subtract Step 2: Copy + paste; drag new object away; scale new object to 0.85-0.9 (smaller than piece removed for box bottom); change to side view + raise on z axis; drag back inside original; center from top view; subtract

MODULE 3: EXPORT AS TWO OBJECTS

GOAL

Export + Prep Both Objects to Print Simultaneously

MEDIA

- Play the Tutorial: *Save + Export*
- **OR** Demonstrate export

FACILITATOR STEP-BY-STEP

TALKING POINTS

- This project can be saved here in 123D for use in the next project. Label it + save in the Main Menu in an easily accessible place.
- It is possible for the printer's software to make the print of both objects at the same time, but they must be exported separately.
- Select and delete the lid.
- In the Main Menu, select Export as STL and label the object as the box.
- Ctrl + Z to undo the delete of the lid, returning it to the 123D grid plane.
- Delete the box and follow the same steps to export the lid, again labeling it clearly.

STEPS COVERED IN MODULE 5

Participants should have completed the following steps when you are ready to move on:

Save + Export: Save file; delete lid + export SVG of box; ctrl + z; delete box + export lid

MODULE 6: PRINT TWO OBJECTS

GOAL

Prep Both Objects to Print Simultaneously

MEDIA

- Play the Tutorial: *Print*
- **OR** Demonstrate print setup and print

TALKING POINTS

- Open MakerWare and select Add File. Find the box file you saved earlier and select it, accepting the prompt to place it on the platform.
- Select Add File again and choose the lid. The Software will center the lid in the same space as the box, so with it still selected, use the Move menu on the left to move it over to the side.
- Find the Export Print File tab on the top toolbar. An Export pop up will appear and load the file to export to the printer. After it is fully loaded, the pop up will display the print time. For our purposes, a 20 minute print time is ideal, so you will may have to cancel out of the export and return to the Scale Tab on the side menu. Once you have achieved a print time near 20 minutes, complete the export to printer.

STEPS COVERED IN MODULE 6

Participants should have completed the following steps to finish the project:

Print: Open MakerWare; Add File for the Box; Add File for the lid; move the lid; Export and check print time; cancel and scale if necessary.

