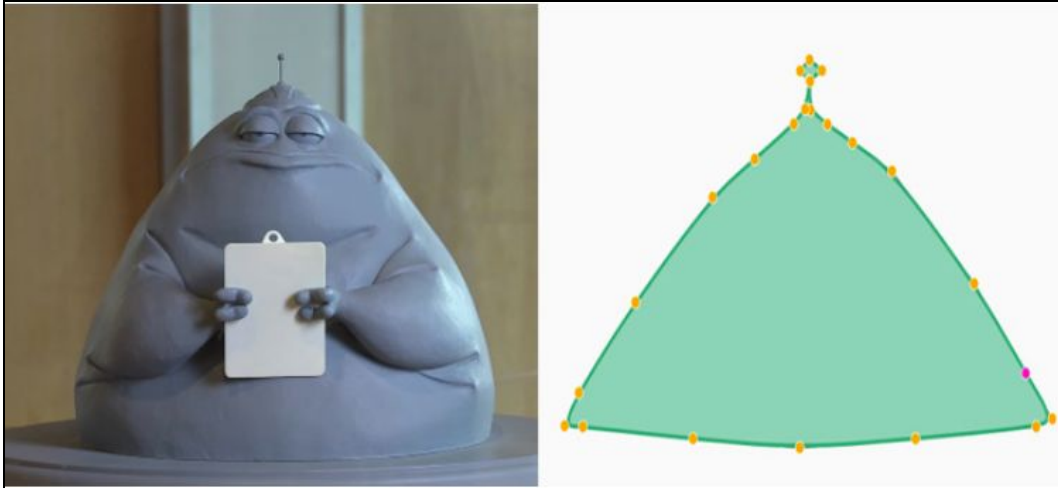# CHARACTER MODELING: FIRST LESSON (link to lesson)

Standards alignment: Common Core: HSG.GPE.B.6, HSG.MG.A.3

Summary/Overview:
Discover one of Pixar's key modeling technologies: subdivision surfaces. This lesson introduces the split and average operations used to make smooth surfaces.

Lesson Structure: This lesson contains 6 videos and 5 exercises which alternate back and forth. One way to run this is to watch and discuss all videos as a group (using a screen at the front of the room) while letting students return to their computers to do the exercises when required.

Total Time Recommended:
Approximately 60-120 minutes to complete the videos and exercises.

Age: Grade 5 - infinity and beyond!

Objectives:
In this lesson, students will:
- Explore how clay models are used in the creation of digital characters using weighted averages
- Design their own character using digital modeling tools

Materials Needed:
- Indoor classroom, lab, or open space with seating and access to the Internet. Space should have enough seating, ideally facing a teacher/facilitator's projection screen.
- Teacher/facilitator should have a computer connected to a large monitor or projector and speakers.
- This lesson assumes that each student or pair of students will require a device to access the lessons online.

VIDEO 0: Introduction to Subdivision Surfaces (length: 2 mins)

Instructions: Have everyone sit where they can see the screen. From the lesson page, play the video "Introduction to Subdivision Surfaces." When the video ends, start a discussion with your group using questions below.

Key terms / Vocabulary:

- **Modeling** - Creating a virtual three-dimensional shape in the computer (helps to make a character look more organic and less "computery")
- **Subdivision** - A mathematical algorithm used to make smooth shapes. It includes the use of:
    - **Split step** - Adding midpoints along each line
    - **Averaging step** - A way to make the shape a little smoother by sliding each point halfway to its right neighbor.

Discussion questions (5 mins):

- **Q:** What is a split step?
- **A:** Points are added halfway between each pair of neighbouring points.
- **Q:** Does everyone understand the difference between 2 dimensional and 3 dimensional?
- **A:** To help illustrate this, draw a square and a cube and ask students which is which (hint, cube has depth and square is flat…)
- **Q:** How does subdivision help animators control characters?
- **A:** It allows you to animate the whole curve just by moving the original four points.
- **Q:** Can subdivision be used on both two-dimensional curves and three-dimensional surfaces?
- **A:** Yes, yes it can!

VIDEO 1: Split vs. Average (length: 4 mins)

Instructions: First we need to make sure we understand exactly what happens in the split & average steps. Have everyone sit where they can see the screen. From the lesson page, play the video "Split vs. Average" When the video ends, start a discussion with your group using questions below.

Note: This lesson references the [Environment Modeling Lesson](#) (parabolas) but isn't required to work on Character Modeling.

Key terms / Vocabulary:
- **Character modeler** - A person in the Character Department who creates the virtual characters that animators use to bring to life.

Discussion Questions (5-10 mins):
- **Q:** In the movie "Up", how do character animators help tell the story of Carl and Russell through the *shapes* of their bodies?
- **A:** Carl's body is designed like a box because he's boxed in with all of the emotions from the hard times that he's had in life. Squares are also stable, rational, earthbound and predictable. Russell is round, shaped like an egg. Round shapes can symbolize warmth, harmony, completeness, grace and comfort.
- **Q:** Can you think of any other characters from UP whose shapes are symbolic of their personalities?
- **A:** You may consider showing this [video on Shape](#) (length: 6 mins) from The Art of Storytelling lesson 4: Visual Language before having students answer. You can also share the image above of characters from "Up" and have students try matching the characters' shapes with their personalities
- **Q:** In the process of subdivision, what are some differences between split step and averaging step? What are some similarities?
- **A:** *Differences* - A split step is the first part of subdivision, the averaging step comes after you add the midpoint. *Similarities* - both split steps and averaging steps contribute towards helping curves become smoother

INTERACTIVE 1: Split and Average (length: 5 mins)

Instructions: Try to make a smile shape by moving the nodes and using Split and Average buttons. After students are nearly finished, follow up with some questions to help check for understanding before moving on.

Exercise Questions (5 mins):

- **Q:** What is the minimum number of splits and averages (subdivisions) needed in order to get the curve smooth enough to mimic the smile shape?
- **A:** Three
- **Q:** Can you get a curve simply by splitting the lines?
- **A:** No, you need to average after every split.
- **Q:** What is the process of split and average called?
- **A:** Subdivision
- **Q:** Can you place the nodes where you think they belong *before* subdividing?
- **A:** Yes, with varying results!

VIDEO 2: Subdivide Operation (length: 2 mins)

Instructions: Now we can combine split and average into a single operation called Subdivide.

Note: This lesson references [Midpoints](#) and [Environment Modeling](#), but isn't required in order to proceed

Key terms / Vocabulary:
- **Subdivide -** A single operation that combines a split followed by an average. Each subdivision step doubles the number of points in the shape
- **Midpoint** - Middle point found by averaging coordinates

Discussion Questions:
- **Q:** Can you make a perfect circle if you continue subdividing?
- **A:** Not a perfect circle, but it comes very close in appearance!
- **Q:** What do the green dots represent in the video?
- **A:** The green dots indicate the beginning and end of each line segment
- **Q:** True or false: Subdivision is the same as splitting, followed by dividing by an average
- **A:** True, it combines both steps into this single step

PRACTICE: Subdivision (length 5 mins)

Instructions: Match each shape with the number of control points used to make that shape. It may be useful to clarify or illustrate that control points are required for each *concave* and each *convex* region in a shape. The more complicated the shape, the more control points are required.
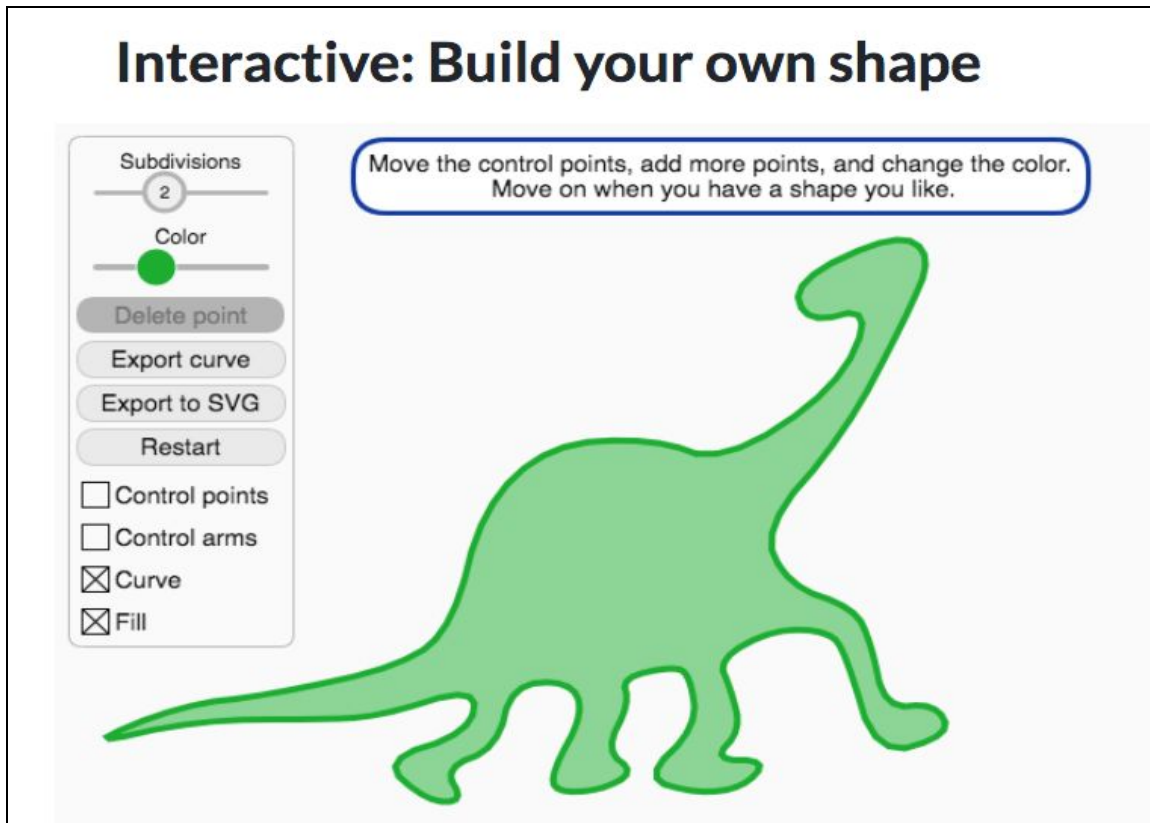
Key terms / Vocabulary:
- **Concave -** having an outline or surface curved *outward*
- **Convex -** having an outline or surface that curves *inward*

Exercise Questions:
- **Q:** How can you figure out how many points will be in a final shape?
- **A:** You can count the number of curves, or ask students to select the hints while they're working through the questions and ask volunteers to share what they learned with the group.
- **Q:** Adding just a midpoint is called what?
- **A:** Splitting
- **Q:** By using an infinite number of subdivisions, you make the curve _____?
- **A:** Smoother (not smaller, not larger)

VIDEO 3: Subdividing your own designs (length: 2 mins)

Instructions: Now you are ready to start subdividing your own shapes with more than 4 points! Have everyone sit where they can see the screen. From the lesson page, play the video "Subdividing your own designs" When the video ends, have students return to their computers to make a shape using the interactive. **(10-20 mins)**

Interactive: Build your own shape

Subdivisions
2

Color

Delete point
Export curve
Export to SVG
Restart
☐ Control points
☐ Control arms
☒ Curve
☒ Fill

Move the control points, add more points, and change the color. Move on when you have a shape you like.

Exercise Questions:
- **Q:** What (or whom) are you going to try and create?

INTERACTIVE 2: Build your own shape (length: 10-20 mins)

Instructions: Create your own design using as many control points as you need. You can smooth the shape by increasing the number of subdivisions

Exercise Prompts:

- Some ideas to riff off of Alonso's, might include:
  - Shape of a fish from Finding Nemo
  - Outline of Carl or Russell's body
  - The shape of Carl & Ellie's house
  - Eva or Wall-e
  - Baby Jack Jack from Incredibles

- If students need more direction, offer these additional challenges:
  - Create an image that has 10 points and 5 subdivisions
  - Create an angular, angry shape with only 1 subdivision
  - Can you create the first letter of your name?
  - Change the color from green to something else
  - Deselect the Control Points and Control Arms in order to show your shape more clearly
  - Take a screenshot of your shapes, or just share your screen with the rest of the group

VIDEO 4: Subdivision in 3D (length: 3 mins)

Instructions: Now let's think about how subdivision would work in 3D.

Key terms / Vocabulary:

- **Facets** - One side of something many-sided

Discussion Questions:

- **Q:** When did Pixar first use the process of subdivision?
- **A:** On the movie "Geri's Game"
- **Q:** Can you use subdivision for things other than characters?
- **A:** Yes, it is used for buildings in "The Incredibles"
- ***Bonus Questions***
    - **Q:** How is splitting in 3D *different* than splitting in 2D?
    - **A:** In addition to splitting midpoints of the edges of a shape, the midpoints of the facets are also computed by averaging all of the coordinates of the control points surrounding it.

INTERACTIVE 3: Subdivision in 3D (length: 10-15 mins)

Instructions: Practice subdividing different shapes, starting with a cube, then a doughnut, then a hand! Move around your shape by clicking and dragging on the background to see different angles. Try experimenting with toggling the controls (control points, control arms, edges, fill, grid) on and off to see how your view changes.

Key terms / Vocabulary:

- **Facets** - One side of something that is many-sided

Suggested Questions:

- **Q:** What scale number could you use to make the cube appear farthest away?
- **A:** 0.25 is the smallest scale number
- **Q:** Can you reposition your shape if the *control points* are hidden?
- **A:** No, but you can continue to modify the shape by *averaging.*
- **Q:** What are advantages of hiding the fill when you're redesigning your shape?
- **A:** You can use the grid to help with alignment
- **Q:** What's the maximum number of times you can subdivide?
- **A:** Three, but you can continue to average
- **Q:** Can you give the hand long, pointy fingers?
- **A:** Yes, but it will take some patience and persistence!
- Ask for volunteers to share their work.

PRACTICE: Subdivision in 3D (length: 10-15 mins)

Instructions: Answer questions to 7 problems covering some of the key concepts of Subdivision. You are welcome to try using the calculator if you want.

Key terms / Vocabulary:

- **Triangular** - a shape with three sides
- **Quadrilateral** - a shape with four sides
- **Pentagonal** - a shape with five sides

VIDEO 5: Getting to know Alonso Martinez (length: 6 mins)

Instructions: *Now let's think about what makes Alonso tick?* Have everyone sit where they can see the screen. From the lesson page, play the video "Getting to know Alonso Martinez." When the video ends, start a discussion with your group using questions below.

Discussion Questions:

- **Q:** When Alonso was a kid, he liked to draw on his shoe and up his leg. Do you have a favorite, "unconventional" drawing surface?
- **Q:** Why do you think Alonso's dad didn't really want him to do much art stuff? Has anyone ever said that to you? How did you feel or respond? (open-ended)
- **Q:** How many ways do you think you could make a living from art? What are some careers that artists can pursue?
- **A:** Check out the ART CAREER project for ideas
- **Q:** Alonso finds exciting ways to combine art and technology making robots. Have you ever tried making a robot? Do you like to tinker?
- **Q:** Have you ever taught yourself something mechanical just by looking online first? (open-ended)